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# SOME ASPECTS OF PARSI DEMOGRAPHY[1]

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## THEIR BACKGROUND

THE Parsi community in India forms but a small fraction of the total population of the country. In 1941 roughly one in 4000 Indians was a Parsi. Yet this community has produced many illustrious personalities who have left an indelible mark on India's march to freedom and progress. Dr. Dadabhoy Naoroji, acclaimed as the "grand old man of India," and the first Indian to sit in the House of Commons, was a Parsi. So was Sir Pherozeshah Mehta, a valiant fighter for India's freedom and one of the Presidents of the Indian National Congress. Jamshedjee Nusservanjee Tata, a great pioneer of Indian industry and the founder of the House of Tatas, well-known today for its preeminent position in Indian industry, was a Parsi. So was Sir Sorabji Pochkhanwala, the doyen of India's banking. Amongst others from this community who have illumined the Indian horizon stand out figures like Shapurji

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Saklatwala, the well-known labour leader, and Behramji Malabari, the great social reformer.

This community, which is close and compact but liberal in its views, and which has not only fought against foreign domination but worked for social amelioration, had a dramatic origin. The Parsis first came to India as fugitives who had left their homeland to preserve their religious faith, and like the Pilgrim Fathers they were inheritors of a great and powerful civilisation and were men of extraordinary ability and great adaptability. Their forbears had once ruled over an empire half as big as the Europe of the last century.

The Parsis were originally inhabitants of Iran, and are able to trace their lineage even prior to 3000 B. C., when the kings of Mahabad ruled over Iran. About 3000 B. C., Hoshang founded the Pishdadian dynasty. It was during his reign that Iranian civilisation was firmly set on its feet and agriculture and irrigation developed. He was also a patron of learning and interested himself in theology and metaphysics. Iran's progress was temporarily arrested when the country passed from the Pishdadians into the hands of Zohak, a Semitic prince, whose descendants held sway over the land for a thousand years till it was liberated by Faridun.

The Kianian dynasty which followed ruled over Iran for about thirteen centuries. The famous warriors Rustom and Soharab, immortalised in Firdousi's "Shah Namah," belonged to the house of Sam, that flourished during this period. It was also during this period that Zoroaster, the great Iranian teacher and prophet, interpreted the Mazdayasnan religion in the light of Zoroastrian theology, whose tenets the Parsis to this day uphold and follow zealously.

Thereafter a number of dynasties ruled over Iran, the two prominent ones being the Achaemenian and the Sassanian. Cyrus the Great of the Achaemenian dynasty was an ambitious and powerful monarch who reigned about the sixth century before Christ. He re-established the Iranian empire in all its glory, subdued the Lydian monarch, Croesus, compelled obeisance from Asiatic Greece and carried his victorious arms as far as Kashgar. He was also very enlightened and the religious tolerance which he showed to the people he conquered, won for him their admiration. His son Cambyses fulfilled the father's ambition by conquering Egypt. Darius Hystaspes, another monarch of repute, extended the empire from Macedonia to the Indus valley.

The Sassanian dynasty was the last one to rule over Iran. Noshirwan Adal, the best known of this dynasty, was a just and wise ruler and, like his illustrious predecessors, extended the empire far and wide. The Iranian empire of his time stretched from territories beyond the Oxus to the Indus valley and even to parts of Arabia. In times of peace Noshirwan Adal built new cities and constructed roads, bridges and canals. Like many of the Iranian monarchs, he was a great patron of art and culture. His fame as a scholar spread as far as China and India. In the famous academy at Jund-i-Shapur, established by him, learned men from all over the world gathered to study literature, medicine and philosophy. The thirst for knowledge, and the high level of culture and scholarship that existed in Iran at that period resulted in the best works in Sanskrit and Greek being translated into Pahlavi at this academy. Iran had also much to contribute to the culture of neighbouring countries and the effect of Sassanian architecture on the Indian is well known to students of mediaeval Indian history.

Noshirwan's glorious reign was like the last flicker of the flame. His successors became indolent and pleasure-loving and fell an easy prey to foreign invaders. The last Sassanian king, Yezdegard Shehrear, was defeated in the Battle of Nehavand in 641 A. D. From that date Iran passed into the hands of the Arabian kings and remains, to this day, a predominantly Mahomedan country. It was indeed an irony of fate that Iranians, whose monarchs had treated the people they conquered with great religious toleration, were themselves given a choice between extermination and conversion to the new faith. Many preferred the sword to the Koran and many more embraced Islam; but a small, valiant band of assiduous adherents of Zoroastrianism, to preserve their sacred fire and faith, set sail in search of a new home where there would be no fear of persecution. Peregrinating along the coast of the Persian Gulf for nearly a century, these fugitives, or rather their descendants, reached Div, a small island on the southern border of Kathiawar. After staying in Div for about two decades, they set sail towards the Malabar coast and landed at Sanjan, a small town ninety-four miles north of Bombay.

### THEIR PROGRESS AND PROBLEM

India, the land of immense resources, has always warmly received foreigners who come to the country for peaceful purposes. The Iranian refugees soon realised that in the country of the Hindu kings they

could practise their religious faith without fear of persecution and decided to make India their new home. Four years after debarking at Sanjan, they built their first place of worship in the land of their adoption and thus the nucleus of Parsi communal life in India came into being. Partly owing to their adaptability and partly owing to the qualities of the people with whom they had to fraternise, to this day they have enjoyed a relatively peaceful life. From time to time fresh batches of Zoroastrians who found life more difficult in Iran migrated into this country and augmented the size of their community. Even in the decade 1920-30, between 4000 and 5000 Iranians moved into India, and by 1941 the Parsi community in the country (excluding Burma and Aden) had grown to 114,890.

Little is known about the early history of the Parsis in India. It may be surmised, however, that this band of settlers would first have interested themselves only in such activities as would have received the approval of the local people. Agriculture and horticulture are believed to have been their main vocations for a number of years. It is not surprising therefore that for a long time these descendants of a glorious culture led a comparatively uneventful life.

As years rolled by, some members of this community did gain recognition for their exceptional qualities. Nerioshang Dhaval, of the 12th century, was well known for his writings. The Desais of Navsari were very influential under the Maratha and Mahomedan rulers and held sway over the people of that area for a few centuries. Dastur Meherji Rana of Navsari, the erudite religious head of the Parsis, used to be a distinguished participant in the theological discussions held under Akbar's patronage.

With the advent of the British, the Parsis emerged from their dormant state and were able to give full expression to their innate intelligence and genius. After centuries of war and fratricidal factions, India was once again directing her attention to constructive activities, and with the patronage of the new masters of India, the Parsis were able to rise very rapidly to eminence and prosperity. Industrial pursuits became their main interest. They were the first to start textile mills in Bombay. The Tata Iron and Steel Works, the largest of its kind in the British Empire, was also founded by them. Today they are connected with almost all the important fields of Indian industry—textiles, iron and steel, soaps and oils, chemicals and pharmaceuticals, fertilisers, locomotives and aircraft. In their hands, Indian banking

received a powerful impetus and the Central Bank of India, one of the most important banking concerns at the present time, is run mainly by them. In other professions, too, they have distinguished themselves. Two members of their community have had the distinction of being elected to the Fellowship of the Royal Society of England, a coveted honour for a British scientist.

It is also easy to recount the names of Parsis who have distinguished themselves as politicians, lawyers and doctors. As patrons of art and culture they stand unique. The superb Dorabji Tata and Ratan Tata Collections that adorn the Prince of Wales Museum in Bombay impress even exacting critics of art. The Indian Institute of Science in Bangalore, the Tata Institute of Social Sciences in Bombay, and the Tata School of Fundamental Research are all the results of their endeavours and patronage. Parsi philanthropy stands unequalled. The Jamsetjee Jeejeebhoy and the Wadia trusts are but examples of the many such trusts that exist in Bombay. They have established hospitals, set up maternity homes, founded technical institutions and encouraged scholarship. With their wealth and influence they form a powerful group in the country. The allocation of one of the fourteen seats in the Interim Government to this small community is a recognition of its importance in shaping the country's future.

In their pursuit for power and position, the Parsis have had to migrate from one part of the country to another. Their early settlements were in Baroda State, Surat and Broach. About 300 years ago they started moving into Bombay, and this city, which has grown to its present importance largely due to their efforts, is today their main stronghold and is the home of about one-half of this community. The rest of the population is scattered all over India, mainly in the Bombay Presidency, but to a smaller extent in Hyderabad State, Central Provinces, Ajmer Merwara, Bihar, United Provinces and Baluchistan. In the last few years the Punjab has also attracted a fair number of Parsis. Today Parsis, sometimes one or two families only, can be found in most military stations and important towns from Cape Comorin to the Himalayas, from Bombay to the Burma border.

The rapid material advancement of the Parsis in recent years is being achieved at a heavy cost. The community is getting increasingly fragmented. Eighty-nine per cent of the Parsis live in towns. The cosmopolitan life of the urban areas and the lack of constant touch with one's own kith and kin are hardly conducive to the preservation of

community life and social cohesion. The solidarity of the Parsi society is in danger. The very existence of the culture, to preserve which their forefathers underwent untold hardships, is now being threatened. The community is, however, fighting hard to keep up its identity. It has prescribed rigid norms of social and religious behaviour. A Parsi is not allowed to marry outside his community. Nor can he change his religion. No non-Parsi can embrace Zoroastrianism nor, for that matter even enter the portals of the Agiari—the Parsi temple of worship. The community has also long realised that social security is essential if the poor and the indigent are to be kept in the fold. The Parsi Panchayet, whose funds are constantly enriched by the well-to-do sections of the community, has been for over a century a source of financial help for the poorer Parsis. Besides this organisation, over 120 trusts with a total corpus of fifty million rupees are ever anxious to offer relief in one form or another. The children of the poor are given ample opportunities to get themselves educated in charity and semi-charity schools. Facilities are provided for cheap medical and maternity services. Special housing schemes have made it possible for the poor to live in good tenements and it is possible for a poor widow to get lodgings at a monthly rental of only eight annas (about 16 cents).

A culture cannot be preserved for any length of time by the mere imposition of religious and social codes of human behaviour. Nor does its continuance rest merely on the attitude of one section of society, however powerful it may be. It is on the will of the people, their determination to ensure its survival, and the sacrifices and sufferings they are prepared to undergo on this account, that the future of the culture depends. In a closed community like that of the Parsis, this determination must first manifest itself in an anxiety on their part to propagate their race, for, were the population to dwindle, their culture must naturally decay and ultimately die out. Population growth is more intimately connected than is generally realised in deciding the ultimate destiny of a people's culture.

Little is known about the numerical strength of the Parsi population in India prior to the eighties of the last century. In 1863 the Census Act of India was passed. From 1881 onwards, every ten years, a population census has been conducted on a country-wide basis and the Parsi population in India has been separately enumerated. Table 1 gives the Parsi population in India (excluding Aden and Burma) at the different censuses. During the sixty years between 1881 and 1941,

the Parsi population increased by 35 per cent. In the same period India's total population had grown by 56 per cent. Even in England, where according to experts there are signs of a declining population, the growth during this period was about 54 per cent. The rate of increase of the Parsi population has been comparatively slow and the real position is decidedly worse than that indicated by the above figures, for undoubtedly a fair proportion of the increase was due to fresh immigration of Iranian Zoroastrians into India.

A slow increase in a population is a matter for serious consideration, as it may be symptomatic of deleterious biological and social forces

TABLE 1

*The Parsi population in India (excluding Burma and Aden)*

| YEAR | POPULATION |
|---|---|
| 1881 | 85 314 |
| 1891 | 89 490 |
| 1901 | 93 617 |
| 1911 | 99 412 |
| 1921 | 101 075 |
| 1931 | 108 988 |
| 1941 | 114 890 |

which if unchecked might lead to the very extinction of the community. The Parsis with their higher level of culture and rare powers of enterprise have contributed in no small measure to India's advancement, and their failure to keep up in the race for population increase should be a matter of great concern for all Indians. Much more so should it be for the Parsi community itself, for its inability to survive biologically would mean the total annihilation of a civilisation of which the Parsis are justly proud and which they are anxious to preserve.

Consciously or unconsciously every community strives for the survival of its race and it would be a tragedy if unwittingly a community should allow forces to develop which, however fascinating they may seem at the moment, would ultimately lead to its complete eradication. It is therefore necessary that every intelligent person, and in particular those guardians of society who have the authority and influence to mould public opinion and evolve social policies, should be fully apprised

of the demographic trends in their community and the factors responsible for them.

If we leave aside migration, population changes are determined by the fertility and mortality conditions prevailing in a community. Unless the number of births offsets the loss of population due to deaths, the population must diminish. Fertility and mortality conditions and their relative effects are therefore of paramount importance in reckoning the survival of the community. These conditions are influenced by a number of factors. The social system, the economic conditions, the state of public health, and above all the average person's sense of values, affect his desire to reproduce and his ability to prolong human life. With the passage of time socio-economic conditions have changed. Medicine has advanced and also its application for the improvement of public health. Individual and social values of today are very different from those of a generation ago. These changes have their repercussions on the fertility and mortality conditions of every community. The trends which these features are exhibiting in the Parsi community and the effect they are likely to have on population growth are matters of great interest for those concerned with the progress of the Parsi community and the preservation of Parsi culture.

## PARSI REPRODUCTIVE BEHAVIOUR

The changes in the reproductive behaviour of a community can to some extent be seen by the trend in the birth rate. To obtain the birth rate for the Parsi community it would be necessary to compile the total number of births during the year by putting together the births that occured in all parts of India, whether in the British zone or Indian States, in towns or in villages; this is no easy task even assuming that the figures for births in all areas were available. But in the reports of many municipalities, the Parsi births are not shown under a separate head, so that under existing conditions the calculation of a birth rate for the entire Parsi community in India is practically impossible. The birth rates in some selected areas only, can be taken up for consideration. The birth statistics for the Parsi community in Bombay are given in detail in the Bombay Municipal Health Reports. For a number of decades, as shown in Table 2, a high proportion of the Parsi community in India has been living in this city and a study of the Bombay data therefore should throw much light on the experience of the entire community.

The trend in the birth rate[1] for the Parsis of Bombay City during 1901-44 is shown in Table 3 and Fig. 1. During the 20-year period 1901-20, the birth rate was as high as 25 per 1000 population.[2] In the

TABLE 2

*The Parsi population in Bombay City*

| | | 1941 | 1931 | 1921 | 1911 | 1901 |
|---|---|---|---|---|---|---|
| Bombay City | No. | 59 813 | 57 765 | 52 234 | 50 931 | 46 231 |
| | % | 52.1 | 53.0 | 51.7 | 51.2 | 49.4 |
| Rest of Bombay province including Sind | No. | 30 295 | 31 434 | 30 462 | 29 665 | 29 450 |
| | % | 26.3 | 28.8 | 30.1 | 29.9 | 31.4 |
| Rest of India | No. | 24 782 | 19 789 | 18 379 | 18 816 | 17 936 |
| | % | 21.6 | 18.2 | 18.2 | 18.9 | 19.2 |
| Total | | 114 890 | 108 988 | 101 075 | 99 412 | 93 617 |

decennium 1921-30, a marked reduction in birth rate occurred, and during 1930 the birth rate was only 20 per 1000. In the years that followed, the birth rate declined much further and even prior to the outbreak of the second World War the rate was only 17 per 1000. During the war years, the Parsi community, in common with others in India, recorded low birth rates, and in 1942 the Parsi birth rate was 14 per 1000. In the succeeding two years the birth rate showed some improvement; but it is doubtful if the pre-1920 level will ever be reached in the near future.

[1] The vital statistics in India are very defective even at the present time and no doubt they were much more inaccurate in the past. The statistics of the Parsi community, however, are likely to be of better quality. The Parsi practice of disposing of their dead in their "Towers of Silence" provides an easy method for the registration authorities to obtain data on the deaths. The Parsis do not maintain a special record of the births in their community. Their birth statistics are reasonably complete, for, as is shown later, the intercensal increase in population is well explained by the birth and death rates.

[2] The very low birth rate in the beginning of the century is presumably due to bad economic and health conditions resulting from famine and plague.

Both social and biological factors affect the birth rate. Chief amongst the biological factors is the proportion of women in the reproductive age group. This proportion is likely to change with time and it is of interest to ascertain whether it has fluctuated to any great extent

TABLE 3

*The Parsi birth rate per 1000 population (Bombay City)*

| YEAR | BIRTH RATE | YEAR | BIRTH RATE | YEAR | BIRTH RATE |
|---|---|---|---|---|---|
| 1901 | 24.6 | 1916 | 27.4 | 1931 | 19.0 |
| 1902 | 24.4 | 1917 | 27.4 | 1932 | 20.4 |
| 1903 | 24.9 | 1918 | 26.5 | 1933 | 18.7 |
| 1904 | 27.3 | 1919 | 24.3 | 1934 | 18.9 |
| 1905 | 27.8 | 1920 | 25.5 | 1935 | 19.0 |
| 1906 | 26.8 | 1921 | 22.9 | 1936 | 20.2 |
| 1907 | 27.3 | 1922 | 24.1 | 1937 | 17.0 |
| 1908 | 25.1 | 1923 | 24.6 | 1938 | 17.2 |
| 1909 | 25.5 | 1924 | 23.9 | 1939 | 16.2 |
| 1910 | 27.5 | 1925 | 24.0 | 1940 | 16.6 |
| 1911 | 29.2 | 1926 | 21.7 | 1941 | 16.6 |
| 1912 | 26.5 | 1927 | 21.7 | 1942 | 14.3 |
| 1913 | 25.6 | 1928 | 21.9 | 1943 | 15.7 |
| 1914 | 26.9 | 1929 | 20.4 | 1944 | 19.4 |
| 1915 | 26.5 | 1930 | 20.1 | | |

TABLE 4

*Number of Parsi females 15-45 years of age per 1000 Parsi population*

| | 1901 | 1911 | 1921 | 1931 |
|---|---|---|---|---|
| Number of females between 15-45 years | 240 | 254 | 252 | 247 |

in the Parsi community during the period for which birth rates were considered above. Table 4 gives for the country as a whole the number of Parsi females between 15 and 45 years of age per 1000 population, in the four years 1901, 1911, 1921 and 1931. The variation in these numbers is slight and it may therefore safely be assumed

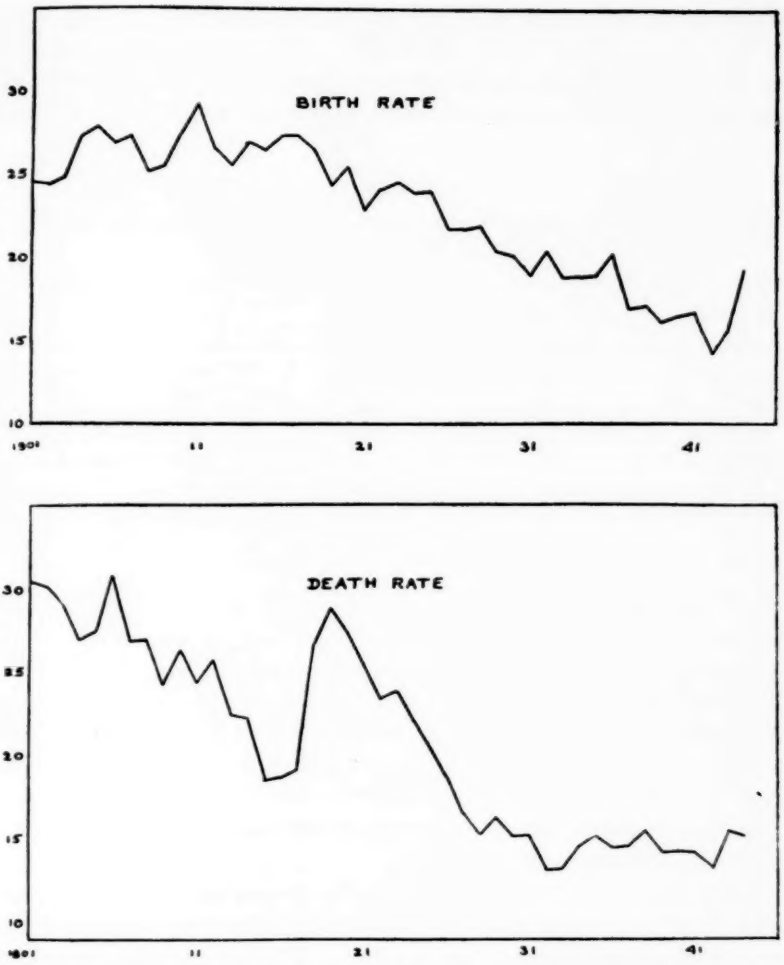


FIG. 1. BIRTH AND DEATH RATES FOR PARSIS IN BOMBAY CITY, 1901-1944

that there has been no marked change in the potential reproductive capacity of the community in the last few decades.

Social factors therefore appear to have been responsible for the declining birth rate. In civilised communities a disinclination on the part of the couple to have a large number of children is sometimes reflected in their postponing marriage to a more advanced age. The average age at marriage amongst the Parsis in the different decades is not

readily available, though it is procurable from the records in the office of the Registrar of Parsi Marriages. The percentage of married females in the different age groups, as given in the census reports, and reproduced in Table 5, throws some light on this question. In 1901,

TABLE 5

*The percentage of married Parsi females (excluding widows and divorced) in the different age groups*

| AGE GROUP | 1901 | 1911 | 1921 | 1931 |
|---|---|---|---|---|
| 15-19 | 24 | 15 | 15 | 18 |
| 20-24 | 55 | 45 | 44 | 35 |
| 25-29 | 69 | 64 | 64 | 66 |
| 30-34 | 77 | 77 | 73 | 72 |
| 35-44 | 71 | 74 | 73 | 74 |
| 45 and over | 40 | 45 | 48 | 49 |

24 per cent of the women in the age group 15-19 years were married, whereas in 1931 the corresponding figure was 18 per cent. In the age group 20-24 the percentage of married women was reduced from 55 in 1901 to 35 in 1931. Even in the age groups 25-29 and 30-34, the percentage of married women was lower in 1931 as compared with that in 1901. Undoubtedly, there has been a shift in the age at marriage and whereas it was fashionable for Parsi women to marry between the ages 20-24 in 1901, the present tendency is for them to marry between the ages 25-29.

It is interesting to compare the ages at marriage of Parsi women with those of other communities in the East and West. Table 6 gives the percentage of married females in the different age groups amongst the Parsis, Hindus, Muslims and in England and Wales. The Parsi women do not marry as early as their sisters in other communities in India. In fact, the bulk of the Parsi women marry at ages which are in vogue in England. A small proportion of Parsi women marry when they are below 20 years and to this extent their behaviour differs markedly from the English.

The ages at which men marry do not have such a strong influence on the reproductive behaviour of the community as those at which women marry, but they also reflect strongly the social attitude towards

TABLE 6

*The percentage of married females in different communities in 1931*

| AGE GROUP | PARSIS | HINDUS | MUSLIMS | ENGLAND AND WALES |
|---|---|---|---|---|
| 15-19 | 18 | 85 | 85 | 2 |
| 20-24 | 35 | 90 | 91 | 26 |
| 25-29 | 66 | 87 | 90 | 59 |
| 30-34 | 72 | 82 | 85 | 73 |
| 35-44 | 74 | 65 | 69 | 75 |
| 45 and over | 49 | 32 | 35 | 59 |

the responsibilities of married life. Table 7 gives the percentage of married males in the different age groups as it obtained during four censuses. A pronounced shift in the age at marriage of Parsi men had also occurred in the last few decades. Whereas in 1901, nearly 25 per cent of the males in the age group 20-24 were married, the corresponding figure in 1931 was only 14 per cent. Even by the age of 35, the lag was not made up as the percentage of married men in the age group 30-34 was 70 in 1901 but only 58 in 1931.

The postponement of marriage usually results in a higher proportion having to remain unmarried for life and therefore it is not

TABLE 7

*The percentage of married Parsi males in the different age groups*

| AGE GROUP | 1901 | 1911 | 1921 | 1931 |
|---|---|---|---|---|
| 15-19 | 9 | 4 | 4 | 7 |
| 20-24 | 25 | 17 | 16 | 14 |
| 25-29 | 47 | 39 | 37 | 43 |
| 30-34 | 70 | 62 | 62 | 58 |
| 35-39 | 82 | 75 | 70 | 76 |
| 40-44 | 85 | 82 | 80 | 80 |

surprising that the percentage of Parsi women who remained single till they passed their reproductive stage was higher in 1931 than in 1901. In 1901, 6 per cent of the women in the age group 45-49 were un-

married whereas in 1931, 16 per cent in this age group were found to remain single. This latter figure is very close to the 17 per cent found in England and Wales.

An increase in the age at marriage diminishes the number of years left over for childbearing and may, therefore, serve as a means for lowering the birth rate. The Parsis not only did put off their marriages to more advanced ages, but also effected a marked reduction in the fertility of their married women. In Bombay City, for instance, the number of births per 1000 women was 190 in 1901, 218 in 1911, 160 in 1921 and 139 in 1931. The decline in the Parsi birth rate may thus be said to have been deliberately brought about by the individuals constituting the community.

In a capitalistic society, the main justification for the desire to have a small family is economic stringency. The economic position of the Parsi community, therefore, deserves the closest study. Though it is apparent that some Parsi families are fabulously rich, it is not so clear whether this community is exempt from the disparity of incomes which marks others in India and whether some families find it difficult even to satisfy their normal requirements. A general idea of the economic well-being of a community is given by the figures for the "gainfully occupied" in the community. According to the 1931 census report of the Bombay Presidency, the number of "gainfully occupied" Parsi males was 25,418. Considering that the Parsi males enumerated in the age group 20-55 years was only 25,136, it can safely be presumed that lack of gainful occupation amongst Parsi males is rare. Five per cent of the Parsi women in the age group 20-55 years were also returned as "gainfully occupied." Gainful employment is an inducement to married life; but unless the income is large enough to allow a decent standard of living a large family is likely to be avoided as a great burden. Table 8 shows the percentage of Parsis employed in various occupations. Over 28 per cent are employed in "Trade" and "Industry." "Transport" accounts for another 18 per cent. Over 9 per cent work as "Domestic servants" and another 10 per cent in "Insufficiently described occupations," which may be presumed to be of a very minor nature. Business can hardly be expected to yield a steady income and it is possible that a number employed in this field find life quite trying. It is also likely that the 19 per cent classed under "Domestic servants" or "Insufficiently classified occupations" may quite often find themselves unable to make both ends meet. No wonder that the Parsi

Panchayet records that 8 per cent, or about 5000 persons, in Bombay require constant financial help from them and that 10,000 to 15,000 from the community live in chronic want. However much economic conditions amongst the Parsis might be better than those of other communities in India, it is obvious that the poorer section cannot be said to have secured for itself freedom from want.

TABLE 8

*The number of Parsis engaged in the various occupations in Bombay Presidency in 1931*

| OCCUPATION | MALES | | FEMALES | |
|---|---|---|---|---|
| | Number | Per cent | Number | Per cent |
| Trade | 6 935 | 25.7 | 878 | 58.1 |
| Exploitation of animals and vegetation | 2 139 | 7.9 | 142 | 9.4 |
| Exploitation of minerals | 522 | 1.9 | 13 | 0.9 |
| Industry | 771 | 2.9 | 44 | 2.9 |
| Transport | 4 945 | 18.3 | 14 | 0.9 |
| Public force | 557 | 2.1 | .. | .. |
| Public administration | 2 584 | 9.6 | 36 | 2.4 |
| Professional and liberal arts | 1 821 | 6.8 | 212 | 14.0 |
| Persons living on their incomes | 1 442 | 5.3 | 68 | 4.5 |
| Domestic servants | 2 498 | 9.3 | 81 | 5.4 |
| Insufficiently described occupations | 2 646 | 9.8 | 13 | 0.9 |
| Unproductive | 102 | 0.4 | 10 | 0.7 |
| Total employed | 26 962 | | 1 511 | |
| Non-working dependents | 20 003 | | 42 191 | |
| Total population | 46 965 | | 43 702 | |

Seventy years ago only one per cent of the population asked for help from the Parsi Panchayet. At the present time 40 per cent require assistance in one form or another. Whether this increase shows a real deterioration in the economic conditions, or whether it merely reflects a growing desire on the part of the Parsis to have a higher standard

of living, it is difficult to say. In any case, its effect on reproductive behaviour is clear. The community is a very enlightened one. In 1931 about 92 per cent of the males and 80 per cent of the females over 15 years of age were literate, a standard of literacy which compares favourably with that of advanced communities in the West. The bulk of the community feel that their income is not adequate to their needs. For a poor but enlightened community, the saying

> "When the horn of plenty is empty
> Nature fills it with babies."

does not hold good. On the contrary, the size of the family is restricted by determined effort. The age at marriage of the Parsis is going up. A natural corollary is the voluntary attempt on the part of the married to prevent reproduction. No wonder that the Parsi birth rate has declined.

## HEALTH OF THE PARSIS

A general idea of the health conditions in a community is obtained from its death rate. The annual death rates of the Parsi community in Bombay for the years 1901-44 are shown in Table 9 and their trend in Fig. 1. Except for a break during 1918-25 when, due to the after-effects of the first World War, including the widespread influenza epidemic of 1918-21, health conditions deteriorated in most parts of the world, the death rate declined consistently from the beginning of the century till 1930. Whereas in 1901, the death rate was 30 per 1000, by 1910 the rate had diminished to 25 per 1000 and by 1930 to 15 per 1000. From 1930 onwards the rate has more or less remained constant at the 15 per 1000 level.

A reduction in the general death rate does mean an improvement in the mortality conditions of at least certain age groups but the social implications of improved health conditions in the different age groups are different. The risk to life is greatest during the first year after birth and a diminution in infant mortality will add substantially to the average length of life. A reduction in the adult mortality rate will add much to the social and economic well-being of the community as fewer families will be left helpless by the death of the father or the mother in the prime of life, and more children will grow up in an atmosphere of innate love and affection and of kindly care and upbringing. The saving in old age is mainly humanitarian and has

TABLE 9

*Death, infant mortality and neonatal mortality rates for Parsis in Bombay City*

| YEAR | DEATH RATE PER 1000 POPULATION | INFANT MORTALITY RATE PER 1000 LIVE BIRTHS | NEONATAL MORTALITY RATE PER 1000 LIVE BIRTHS |
|---|---|---|---|
| 1901 | 30.5 | 219 | 67 |
| 1902 | 30.2 | 263 | 93 |
| 1903 | 29.1 | 194 | 65 |
| 1904 | 27.0 | | |
| 1905 | 27.5 | NOT AVAILABLE | |
| 1906 | 30.8 | | |
| 1907 | 26.8 | | |
| 1908 | 26.9 | 231 | 66 |
| 1909 | 24.3 | 189 | 75 |
| 1910 | 26.4 | 217 | 73 |
| 1911 | 24.4 | 186 | 60 |
| 1912 | 25.7 | 206 | 58 |
| 1913 | 22.4 | 188 | 66 |
| 1914 | 22.1 | 174 | 53 |
| 1915 | 18.6 | 153 | 50 |
| 1916 | 18.8 | 130 | 41 |
| 1917 | 19.2 | 142 | 47 |
| 1918 | 26.6 | 163 | 48 |
| 1919 | 28.9 | 225 | 76 |
| 1920 | 27.4 | 199 | 59 |
| 1921 | 31.0 | 245 | 75 |
| 1922 | 23.3 | 143 | 56 |
| 1923 | 23.8 | 168 | 58 |
| 1924 | 22.0 | 163 | 66 |
| 1925 | 20.4 | 156 | 56 |
| 1926 | 18.7 | 143 | 52 |
| 1927 | 16.6 | 114 | 40 |
| 1928 | 15.3 | 112 | 45 |
| 1929 | 16.3 | 95 | 34 |
| 1930 | 15.1 | 99 | 30 |
| 1931 | 15.2 | 118 | 43 |
| 1932 | 13.1 | 78 | 27 |
| 1933 | 13.2 | 102 | 41 |
| 1934 | 14.6 | 95 | 32 |
| 1935 | 15.2 | 92 | 46 |
| 1936 | 14.5 | 79 | 32 |
| 1937 | 14.6 | 107 | 47 |
| 1938 | 15.6 | 111 | 37 |
| 1939 | 14.2 | 101 | 50 |
| 1940 | 14.2 | 95 | 51 |
| 1941 | 14.1 | 72 | 32 |
| 1942 | 13.3 | 92 | 46 |
| 1943 | 15.5 | 84 | 46 |
| 1944 | 15.1 | 68 | 33 |

little material value as by then most people cease to be productive and often become a liability. The trends in mortality conditions amongst the different age groups are therefore of particular interest.

The infant mortality rates for the years 1901-44 are given in Table 9 and in Fig. 2. Prior to 1925 the rate was invariably over 150 per

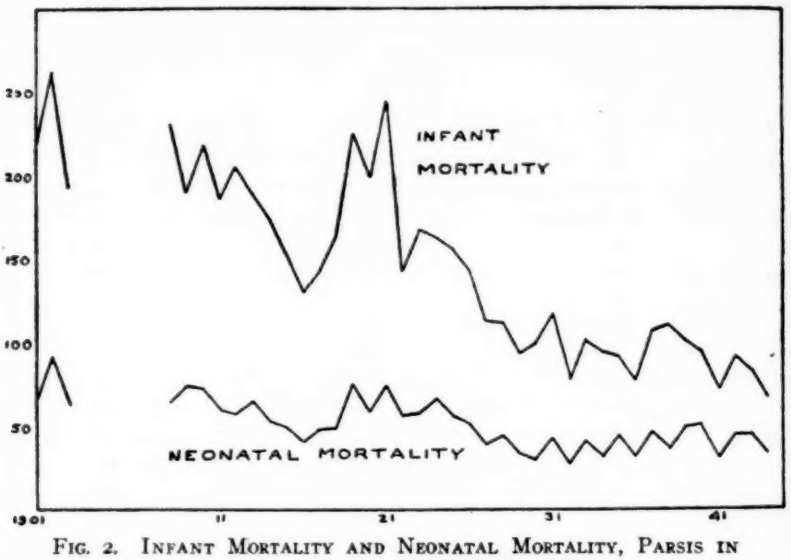


FIG. 2. INFANT MORTALITY AND NEONATAL MORTALITY, PARSIS IN BOMBAY CITY, 1901-1944

1000 live births and in a number of years the figure exceeded the 200 mark. At that time, then, one out of every six infants born died before completing the first year of life. From 1925 the infant mortality rate declined rapidly. In the thirties the rate was about 100. In 1940, the rate was 95 and in the four years that followed the infant mortality rate declined still further to 68 per 1000 live births in 1944. The current Parsi infant mortality rate stands in marked contrast with the figure of 200 per 1000 recorded during 1943-44 for all communities in Bombay and compares favourably with the rates for some of the countries in western Europe.

Infants being most sensitive to adverse environmental factors, the infant mortality rate is a good index of the health conditions in an area. If the deaths occurring within the first year of life are reckoned

under the two heads—those taking place prior to the completion of the first month of life, and the rest—a fair idea of even the standard of life in a community can be obtained. The neonatal deaths, those occurring in the first month of life, are often caused by the poor health of the mother and bad obstetrical service. The post-neonatal deaths are mainly the results of inimical environmental conditions, including unhygienic housing, improper sewage disposal, lack of filtered water supply, and an inability to avoid unwholesome food. A reduction in the infant mortality rate which is due largely to a diminution in the neonatal mortality may mean only an improvement in antenatal and midwifery service, but a substantial reduction in both neonatal and post-neonatal mortality rates would signify an overall improvement in socio-economic conditions and a general increase in the standard of living.

The trend in the neonatal mortality rate for the Parsi community is shown in Table 9 and Fig. 2. The neonatal mortality rate came down from an average of 66 per 1000 in 1908-12 to 42 per 1000 during 1940-44. The rate for 1944 was only 33 per 1000 as contrasted with 66 per 1000 for 1908. The post-neonatal mortality has also shown a great decline and whereas its average value for 1908-12 was 139 per 1000, the corresponding figure for 1940-44 was 41 per 1000. The simultaneous diminution in both the mortality rates leads one to believe that conditions of life have improved considerably amongst the Parsis. This presumption is also justified by the decrease in the mortality rates of all age groups below 60 years during the past few decades as shown by the figures in Table 10. Compared with the rates in the decennium 1901-10, those in 1931-40 were roughly one-fourth for age groups below 40 years and for those between 40 and 60 years the rates were one-half. For the age group over 60, there was no change.

The trends in the rates of mortality due to different causes could indicate very succinctly the directions in which the health conditions have improved. To the extent possible, comparable figures for the death rates due to different groups of causes for five-year periods have been presented in Table 11, using the classification suggested by the International Commission on the subject. As the years 1920-24 were abnormal, due to the influenza epidemic and the after-effects of the first World War, figures for this period may be excluded in discussing the trend in the specific death rates due to different causes.

The death rate in the group of infectious and parasitic diseases came down consistently from 268 per 100,000 in 1925-29 to 143 per

100,000 in 1935-39. The important individual causes of this group in 1925 were malaria, tuberculosis of the respiratory system, dysentery, typhoid and paratyphoid. By 1939 practically no deaths resulted from malaria, and deaths due to tuberculosis of the respiratory system and dysentery were halved. There was, however, no substantial reduction in the death rate due to typhoid and paratyphoid fevers. From 1925, deaths from ague and remittent fever, plague and meningococcal meningitis steadily declined, and by 1939 they were practically elimi-

TABLE 10

*Death rates per 1000 population of different age groups*

| AGE GROUP | 1901-10* | 1911-20 | 1921-30 | 1931-40 |
|---|---|---|---|---|
| 1-2 | 210.0 | 190.0 | 120.0 | 40.0 |
| 2-5 | 23.2 | 20.6 | 15.4 | 7.3 |
| 5-10 | 7.4 | 6.2 | 5.4 | 3.1 |
| 10-15 | 8.0 | 4.5 | 3.4 | 1.9 |
| 15-20 | 11.1 | 8.6 | 3.8 | 2.2 |
| 20-30 | 12.7 | 9.6 | 6.3 | 3.3 |
| 30-40 | 15.7 | 12.1 | 9.0 | 4.9 |
| 40-50 | 21.2 | 17.6 | 15.1 | 8.6 |
| 50-60 | 36.9 | 29.1 | 29.2 | 21.7 |
| Over 60 | 99.2 | 86.7 | 95.0 | 100.0 |

* Excludes figures for 1904-07.

nated. At the present time, smallpox, cholera, measles, whooping cough and diphtheria all record very few deaths, none in some years. Syphilis and leprosy never seem to have been serious problems in this community.

The death rate from malignant cancer has been on the increase. Whereas the rate was 48 per 100,000 in 1925-29, the rate was 61 per 100,000 in 1935-39. Of the diseases of the nervous system and sense organs, cerebral haemorrhage accounts for a large number of deaths. The rate for this group was slightly higher in 1935-39 as compared with 1930-34. Deaths due to diseases of the circulatory system have been on the increase. In 1925-29, the death rate for the group was 56 per 100,000. In 1930-34, the rate increased to 88 per 100,000 and in the five-year period 1935-39, the rate was 125 per 100,000. In the course of about ten years the death rate has more than doubled.

TABLE 11

*Death rates per 100,000 for different groups of causes*

TABLE 11

*Death rates per 100,000 for different groups of causes*

| GROUP | CAUSES | 1920-24 | 1925-29 | 1930-34 | 1935-39 |
|---|---|---|---|---|---|
| I | * Infectious and parasitic diseases | 521 | 268 | 177 | 143 |
| II | † Cancer and other tumours | 42 | 48 | 61 | 61 |
| III | Rheumatism, diseases of nutrition and of endocrine glands, and other general diseases | Separate figures not available | | | |
| IV | Diseases of the blood and blood-forming organs | " | " | " | " |
| V | Chronic poisoning | " | " | " | " |
| VI | ‡ Diseases of the nervous system and sense organs | Not available | | 64 | 78 |
| VII | § Diseases of the circulatory system | 52 | 56 | 88 | 125 |
| VIII | Diseases of the respiratory system | 469 | 292 | 237 | 225 |
| IX | § Diseases of the digestive system | 295 | 169 | 98 | 132 |
| X | \|\| Non-venereal diseases of the genito-urinary system and annexa | 81 | 83 | 71 | 89 |
| XI | Diseases of pregnancy, child birth and the puerperal state | 21 | 17 | 13 | 6 |
| XII | Diseases of the skin and cellular tissue | Separate figures not available | | | |
| XIII | Diseases of the bones and organs of locomotion | " | " | " | " |
| XIV | Congenital malformation | 144 | 96 | 64 | 71 |
| XV | Diseases of early infancy | | | | |
| XVI | Old age | Separate figures not available | | | 156 |
| XVII | Deaths from violence | 55 | 42 | 44 | 54 |
| XVIII | Ill-defined diseases | 92 | 71 | 73 | 104 |
| | Other defined diseases | 774 | 589 | 446 | 240 |
| | All causes | 2546 | 1731 | 1436 | 1484 |

* Excludes tetanus, septicemia, sprue, poliomyelitis and a few others.

† Excludes tumours non-malignant and of undetermined nature.

‡ Figures mainly those for cerebral haemorrhage.

§ Includes more items in 1935-39.

|| Includes figures for acute and chronic nephritis only.

Though part of this increase has been due to the addition of a few minor diseases in this group, there is no doubt that heart disease, the most important of this group, now causes very many more deaths.

The death rate from the diseases of the respiratory system has shown a decline. Pneumonia (all forms), the most important item under this head, claimed as many as 158 deaths in 1925 but only 49 in 1939. The number of deaths due to bronchitis was also reduced from 17 in 1925 to 9 in 1939. Taken as a whole, the death rate due to this group of causes was 292 per 100,000 in 1925-29 and 112 per 100,000 in 1935-39.

The bulk of the deaths due to the diseases of the digestive system are caused by diarrhea and enteritis. Whereas 99 deaths were recorded under this head in 1925, the number in 1939 was only 41. The decline in the death rate due to these two diseases has been consistent.

Of the diseases of the genito-urinary system, only the death rate from acute and chronic nephritis is available. In 1925-29 the death rate due to these causes was 83 per 100,000 and in 1935-39 the rate was 89 per 100,000.

At the present time deaths due to maternal causes are few. Not more than 4 or 5 are recorded for an average number of 1000 births. This standard of maternal mortality compares very favourably with those obtaining in the advanced countries in the West.

The trends in the death rates due to different groups of causes demonstrate beyond doubt that the Parsis have been progressively purchasing better health. Infectious and parasitic diseases thrive in unhygienic surroundings. Proper housing, balanced nutrition, adequate preventive and curative medical services, and above all a highly developed health consciousness in the community are essential if infectious diseases are to be controlled. The Bombay municipal authorities have been handling with great seriousness the health problem in their city, but in spite of their best efforts they have not been able to reduce the death rates from infectious diseases for the entire population to the level of the Parsis. The death rate amongst the Parsis is only a tenth of that amongst the entire population. Their death rates from malaria and tuberculosis are one-third of those prevalent in other communities. Their death rate from respiratory diseases is only a fourth of the Bombay figure. A major cause for these differences is undoubtedly the higher standard of life of the Parsis. An even more important factor is their superiority as a community. Apart from the facilities

they have provided for the education and enlightenment of even the poorer sections, they have launched projects which go a long way to fight infectious diseases. The most conspicuous of these is the construction of Parsi Colonies in Bombay since the beginning of this century where good housing accommodation is provided at a fair rent, particularly to the lower middle class and the poor. The hospital facilities which have been made available by Parsi munificence for all sections of the Bombay population are well known and it is only to be expected that the Parsis of today are themselves able to enjoy high-grade medical care.

Improved standards of living and better health conditions naturally result in an increase in the average length of life. The proportion of persons in the older age groups thereby increases and the diseases to which the aged are more prone also became more prominent. Cancer,

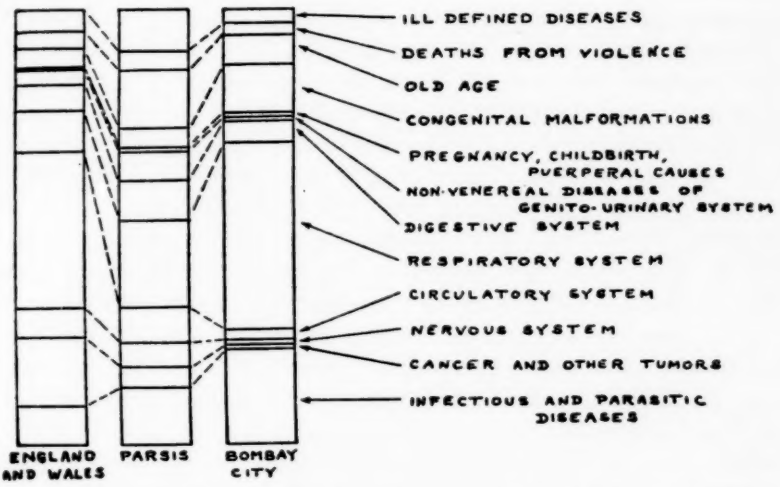


FIG. 3. PROPORTIONS OF DEATHS FROM DIFFERENT CAUSE GROUPS: ENGLAND AND WALES, PARSIS, AND ALL COMMUNITIES IN BOMBAY CITY, 1938

cerebral haemorrhage, diseases of the circulatory and the genito-urinary systems start accounting for a higher proportion of deaths. Many Western countries have exhibited this feature. It is particularly marked in the United States, and in England and Wales. The experience of the Parsis of Bombay is also tending in the same direction. Fig. 3 compares the proportion of deaths under different groups of causes

in England and Wales and for Parsis and all communities in Bombay during 1938.[3] Whereas about 60 per cent of the total deaths in Bombay were accounted for by infectious and parasitic diseases and the diseases of the respiratory system, only 33 per cent of the deaths amongst Parsis came under these two heads. The corresponding percentage for the population in England and Wales was 19. Considering deaths from diseases of old age like cancer, diseases of the nervous system, circulatory system and the non-venereal diseases of the genito-urinary system, it is seen that these formed 4 per cent of the total deaths for the Bombay population, 25 per cent for the Parsis and 61 per cent for England and Wales.

In planning the public health program in any community, the authorities have to take into consideration the relative incidence of the different diseases and the relative ease or difficulty of preventing them. The public health policy in England today is not the same as it was half a century ago. There was a time when easily controllable diseases like smallpox, plague and cholera were taking a heavy toll in that country. The emphasis then was mainly on the improvement of environmental sanitation. Today infectious diseases are relatively less important, and personal health services are therefore receiving as much attention as environmental hygiene. The present Parsi health picture is more akin to that prevailing in England now than that existing in Indian communities. The Parsi public health policy should therefore not be exactly the same as that prescribed for the other Indian communities even in Bombay. Table 12 lists a number of diseases which in 1941 were responsible for a large number of deaths amongst the Parsis. Of these, typhoid and paratyphoid, tuberculosis of the respiratory system, diarrhea and enteritis and dysentery are more easily controllable. It is to be expected that with the attention that the present executive health officer of the Bombay Municipality has shown for the control of these diseases, and with suitable health propaganda, it should be possible within a short time to reduce very considerably the death rate from these diseases in the Parsi community. If personal health services, such as the School Medical Service and the Maternity and Child Welfare Services, are also introduced, and if special facilities are provided

[3] The only explanation that could be found for the fact that the proportion of deaths under "ill defined diseases" was higher amongst Parsis as compared with that for all communities in Bombay City was that their deaths were registered separately at the "Towers of Silence" and possibly with greater accuracy.

to diagnose and treat patients suffering from tuberculosis, cancer, heart disease, etc., the death rate of the Parsi community can be further reduced and the community health brought to the level of advanced countries in the West.

### THE PARSI LENGTH OF LIFE

One of the indices frequently used to describe the health of a community is the average length of life of persons born in it. The greater the average length of life, the better the health of the community, and vice versa. The average length of life, which is more popularly known as the expectation of life, is readily obtainable from a life table. In

TABLE 12

*Deaths due to different causes, Parsis (Bombay City), 1941*

| CAUSE OF DEATH | NUMBER OF DEATHS |
|---|---|
| Typhoid and paratyphoid | 17 |
| Tuberculosis of respiratory system | 17 |
| Tuberculosis, other forms | 8 |
| Cancer of uterus | 2 |
| Cancer of breast | 4 |
| Cancer of all other sites | 30 |
| Diabetes | 39 |
| Intercranial vascular lesions | 50 |
| Heart disease | 54 |
| Pneumonia | 67 |
| Diarrhea and enteritis | 30 |
| Nephritis | 50 |
| Premature birth | 13 |
| Congenital malformation and birth injury | 20 |
| Dysentery | 20 |
| Senility and old age | 115 |
| Other causes | 306 |
| Total | 842 |

India it has been the practice to prepare separate life tables for the populations of the different provinces after the decennial census; but, as far as can be ascertained, no efforts have been made to have such tables prepared for the different communities in the country.

In the absence of separate figures for the Parsi expectation of life, life tables have been constructed for the purpose of a detailed discussion in this paper of their average length of life.

Two sets of life tables were prepared, one for the three-year period 1910-12, and the other for the period 1930-32. As is customary, separate life tables[4] for each period were constructed for males and females. The life tables are presented in Table 13. The figures for survivors are also shown in Fig. 4. In both the periods 1910-12 and 1930-32, the number of survivors was higher amongst females than amongst males at almost all ages. The only exception was at 40 years of age. It is not surprising therefore that the expectation of life at

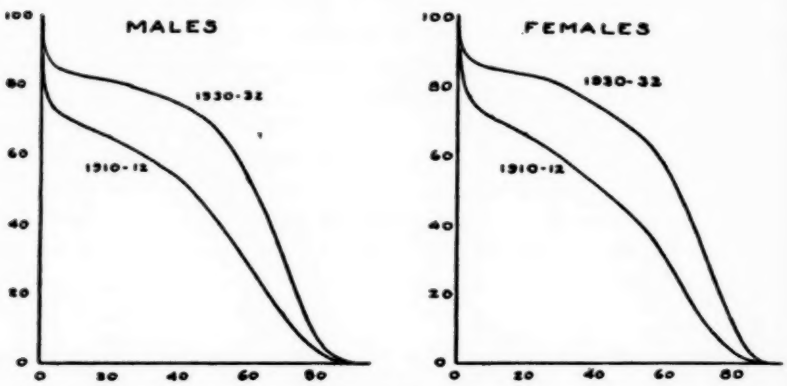


FIG. 4. SURVIVORSHIP DISTRIBUTIONS, PARSIS IN BOMBAY CITY, 1910-1912 AND 1930-1932

birth was higher amongst females in both periods. In 1911 the expectation of life for females exceeded that for males by 0.8 years and in 1931 by 2.0 years. The survivor figures give a good picture of the cumulative effect of the death rates in all the previous ages; but they

[4] The data mainly used were the figures for the Parsi population enumerated in the different age groups in Bombay at the 1911 and 1931 censuses and the mortality statistics for the two triennia 1910-12 and 1930-32. For assessing the survival rate in the age groups below five years, annual birth statistics and death figures of these age groups for a few more years were also used. The survivorship figures for age groups beyond 60 years were obtained by using those of Bombay province, as given in the life tables of the 1911 and 1931 census reports, for graduation.

are not so useful for comparing the risks to life of males and females at different ages. This can be done with the help of the mortality rates given in the life table. In 1911 the female mortality rates were markedly higher in the age group 20-40 and slightly so in the age groups 5-20 and over 60 years. By 1931 the female death rates had shown a greater improvement than the male death rates since it was only in the two age groups 10-20 and 30-40 that the rates continued to be higher amongst females.

The increase in the expectation of life at birth for Parsis during the period 1911 to 1931 was remarkable. In 1911 the expectation of life was 37.6 years for males and by 1931, it had increased to 52.2 years, the excess being 14.6 years. For females the expectation of life was 38.4 years in 1911 and 54.2 years in 1931, the increase being 15.8 years. The Parsi longevity is much higher than that of other communities in India. To enable a comparison, the figures for the Bombay Presidency may be of interest. In this Presidency, the expectation of life for males was 27.8 years and for females 26.4 years in 1931. As in the same year the expectation of life in England and Wales was 58.7 years for the males and 62.9 years for females, the Parsis can be considered to be well on the way to bringing their average length of life to that of the English.

The mortality rates at different ages amongst the Parsis in 1911 and 1931, as obtained from the life tables, are shown graphically in Fig. 5. For comparison, the English mortality rates for 1931 have also been provided. During the course of 20 years, the mortality rates in most age-groups were reduced by one-half. The fall in the death rate was most marked in the age group 10-20 amongst males and 10-30 amongst females. In spite of this substantial reduction, the Parsi death rates in 1931 were still higher than those of the English. The groups showing the greatest disparity were the 0-10 age group of both males and females and the age group 30-40 amongst females. In the former two groups the rates amongst the Parsis were one and a half times the corresponding figures for the English. In the last group, the Parsi mortality rate was double that of the English. It would therefore appear that along with the efforts for a general improvement in the health of the Parsis, special attention should be paid to the health of infants, pre-school and school children and the women in the reproductive age group.

TABLE 13-A

*Life table for Parsis in Bombay, 1910-1912*

| AGE | MALES | | | FEMALES | | |
|---|---|---|---|---|---|---|
| | Number of survivors | Mortality rate (per cent) | Expectation of life | Number of survivors | Mortality rate (per cent) | Expectation of life |
| 0 | 10 000 | 19.1 | 37.6 | 10 000 | 17.2 | 38.4 |
| 1 | 8 090 | 2.7 | 45.4 | 8 283 | 2.5 | 45.3 |
| 5 | 7 204 | 0.6 | 46.1 | 7 454 | 0.7 | 46.2 |
| 10 | 6 976 | 0.6 | 43.4 | 7 188 | 0.7 | 42.9 |
| 20 | 6 534 | 0.9 | 35.9 | 6 692 | 1.1 | 35.6 |
| 30 | 5 947 | 1.1 | 29.0 | 5 979 | 1.3 | 29.2 |
| 40 | 5 294 | 2.0 | 22.0 | 5 176 | 1.6 | 23.0 |
| 50 | 4 241 | 3.4 | 16.1 | 4 347 | 2.9 | 16.3 |
| 60 | 2 805 | 4.8 | 11.4 | 3 105 | 5.2 | 10.6 |
| 70 | 1 460 | 7.3 | 7.0 | 1 491 | 7.8 | 6.6 |
| 80 | 396 | 9.8 | 4.0 | 324 | 9.8 | 3.7 |
| 90 | 10 | ... | 2.5 | 6 | .. | 2.5 |

TABLE 13-B

*Life table for Parsis in Bombay, 1930-1932*

| AGE | MALES | | | FEMALES | | |
|---|---|---|---|---|---|---|
| | Number of survivors | Mortality rate (per cent) | Expectation of life | Number of survivors | Mortality rate (per cent) | Expectation of life |
| 0 | 10 000 | 10.16 | 52.2 | 10 000 | 9.14 | 54.2 |
| 1 | 8 984 | 1.42 | 57.0 | 9 086 | 1.10 | 58.6 |
| 5 | 8 475 | 0.31 | 56.4 | 8 687 | 0.30 | 57.2 |
| 10 | 8 343 | 0.18 | 52.2 | 8 555 | 0.20 | 53.1 |
| 20 | 8 192 | 0.41 | 43.1 | 8 380 | 0.40 | 44.1 |
| 30 | 7 854 | 0.46 | 34.7 | 8 048 | 0.74 | 35.7 |
| 40 | 7 495 | 0.94 | 26.1 | 7 453 | 0.82 | 28.1 |
| 50 | 6 789 | 2.25 | 18.3 | 6 840 | 1.79 | 20.2 |
| 60 | 5 262 | 4.26 | 12.2 | 5 618 | 3.50 | 13.5 |
| 70 | 3 022 | 7.50 | 7.5 | 3 649 | 6.93 | 8.1 |
| 80 | 754 | 9.88 | 5.1 | 1 122 | 9.83 | 5.1 |
| 90 | 9 | ... | 2.5 | 19 | ... | 2.5 |

The improvement of the health of the infants and children deserves great consideration as in general it is the reduction in the mortality in these age groups that adds substantially to the average length of life. Parsi experience also supports this contention. Between 1911

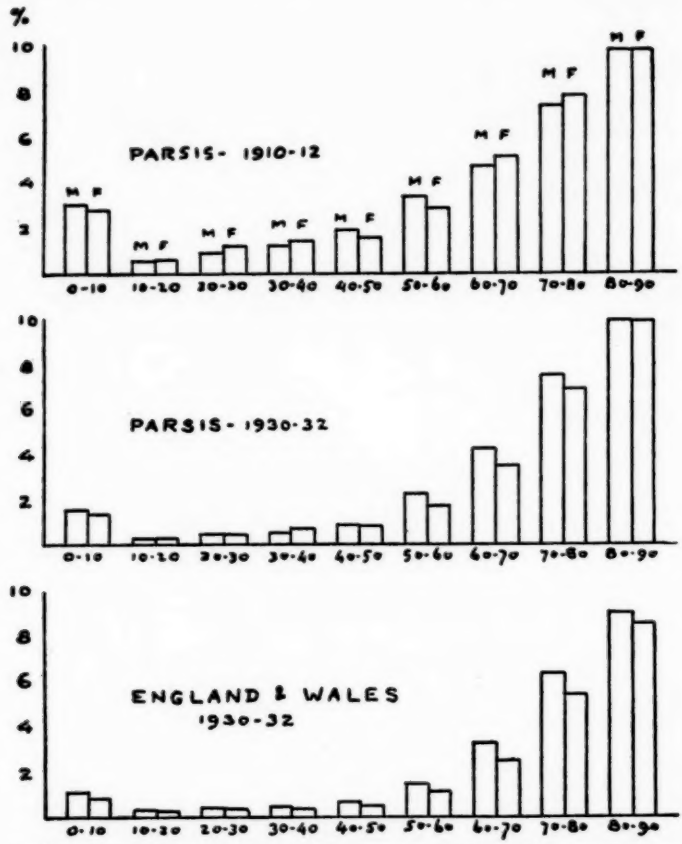


FIG. 5. AVERAGE MORTALITY RATES, PARSIS IN BOMBAY CITY, 1910-1912 AND 1930-1932, AND ENGLAND AND WALES, 1930-1932

and 1931 the extent of reduction in death rate was highest in the age group 10-20 years. But of the total gain of 14.6 years for males and 15.8 years for females in the expectation of life during this period, the part attributable to the reduction of the death rate in the 10-20 age group was only 1.4 years for males and 1.6 years for females.

On the other hand the reduction in infant mortality added 4.2 years to the expectation of life in males and 3.7 years to the expectation of life for females. The contribution [5] of the other age groups to the diminution of mortality is shown in Table 14. The reduction of mortality

TABLE 14

*Contribution to the increase in the expectation of life between 1911 and 1931 by the reduction in mortality in the different age groups*

| AGE GROUP | INCREASE | |
|---|---|---|
| | Males | Females |
| Under 1 | 4.2 | 3.7 |
| 1 | 1.5 | 1.9 |
| 2-4 | 0.2 | 0.6 |
| 5-9 | 1.4 | 0.8 |
| 10-19 | 1.4 | 1.6 |
| 20-29 | 1.4 | 1.9 |
| 30-39 | 1.4 | 1.4 |
| 40-49 | 1.6 | 1.1 |
| 50-59 | 1.1 | 1.1 |
| 60 and over | 0.4 | 1.7 |
| Total increase in expectation of life | 14.6 | 15.8 |

in the first year of life made the largest contribution to the increase in the expectation of life and that in the age group 1-2, the next largest.

The Parsi longevity and its trend are of great significance for public health men in India. The mortality conditions prevailing in the country are so appalling and the task of bringing them to the level of the Western countries so urgent and stupendous, that there has always been a temptation to attribute the higher death rate in India to adverse climatic conditions. The Parsis, though they have been living under much the same geographical conditions, have been able to raise their expectation of life to a level which is not far short of that of Western countries. Here is an achievement which is an example

[5] The contribution, as worked out, gives to an age group the benefit of the increased survivorship at the beginning of the age group resulting from improvement in mortality conditions in the earlier age groups.

and an exhortation to other Indian communities. Will those in power take up the question of India's health in all seriousness, spot out the root causes of the country's ill-health and adopt a bold policy of action which will make the health status of the nation an ideal for others?

## THE PARSI AGE STRUCTURE

The age structure of a population is determined by the manner in which the community has reacted through generations to a number of forces which have had their impact on fertility and mortality conditions and on migration. War and pestilence, industrialisation and urbanisation, religious dogmas, spread of education, change in woman's status, social legislation, sense of social values, all affect birth rate, death rate and migration rate and in doing so disturb the relative proportions of the young, the adult and the aged sections of the population. The age structure of a community is intimately connected with its social well-being and no progressive society can afford to be indifferent to it. A population with a high proportion of the aged will find its finances heavily burdened with demands for such security measures as poor relief, and old age pensions. With a high proportion of children the society will be required to meet additional needs towards facilities for education, school medical help, etc. To the administrator, a knowledge of the age structure is indispensable for the proper planning of the social services. To the public health authorities, it is a necessary guide for a correct orientation of public health programs. To the demographer, it is an excellent yardstick of the biological healthiness of the people, their anxiety to survive in the face of the stress and strain of an increasingly competitive world.

The extent to which two of the factors that influence age structure have been affected during the last few decades amongst the Parsis in Bombay was discussed at length in the foregoing sections.

It was shown that the birth and death rates have declined to a marked extent in recent years. If the Parsis in Bombay could be considered as a closed community so that changes in their population strength due to migration are rendered unimportant, the manner in which the age structure should have changed through the different decades could easily be guessed. The variations should be analogous to those in many Western countries, including England and Wales, which experienced similar trends in birth and death rates. In those

countries the proportion of the population under 15 years of age declined and that above 60 years increased. In the intermediate ages, the proportions changed but little. The age structure of the Parsis in Bombay during 1901, 1911, 1921 and 1931 is shown in Table 15. These distributions have been obtained from the census reports and it is likely that the figures on which they are based are defective, owing both to omissions in census enumeration and the incorrect return of age.

TABLE 15

*The percentage of Parsi population in the various age groups*

| AGE GROUP | 1901 | 1911 | 1921 | 1931 |
|---|---|---|---|---|
| | | *Bombay* | | |
| 0-4 | 8.1 | 7.5 | 6.5 | 7.3 |
| 5-14 | 21.1 | 18.3 | 17.0 | 17.2 |
| 15-44 | 52.8 | 55.7 | 55.2 | 53.5 |
| 45-59 | 12.4 | 12.5 | 14.8 | 15.5 |
| 60 and over | 5.6 | 6.0 | 6.5 | 6.5 |
| | | *Outside Bombay* | | |
| 0-4 | 10.9 | 10.3 | 9.2 | 9.9 |
| 5-14 | 23.7 | 21.7 | 21.6 | 20.3 |
| 15-44 | 47.3 | 48.2 | 47.2 | 47.4 |
| 45-59 | 11.6 | 12.8 | 14.0 | 14.8 |
| 60 and over | 6.5 | 7.0 | 8.0 | 7.6 |
| | | *India* | | |
| 0-4 | 9.5 | 8.8 | 7.9 | 8.5 |
| 5-14 | 22.5 | 20.0 | 19.2 | 18.7 |
| 15-44 | 50.0 | 52.0 | 51.3 | 50.6 |
| 45-59 | 12.0 | 12.7 | 14.4 | 15.2 |
| 60 and over | 6.0 | 6.8 | 7.2 | 7.0 |

If the influence of such deficiencies is ignored, the age structure could for all practical purposes be said to have undergone a systematic change during the years 1901-31. A slight distortion in the trend is noticeable in 1921, presumably due to the influenza pandemic, which did not affect all the age groups equally. In 1901, 29.2 per cent of

the population was under 15 years of age and in 1931 this figure was reduced to 24.5. The population aged 15-45 years did not vary much between 1901 and 1931, being 52.8 per cent in 1901 and 53.5 per cent in 1931. The population over 45 years of age increased from 18 per cent in 1901 to 22.0 per cent in 1931. The change in age structure of the Parsi community in Bombay was thus very similar to that which occurred in England and Wales.

In the absence of the birth and death statistics for the Parsis living outside Bombay City, it is difficult to understand directly the nature of the demographic changes that are occurring in the entire Parsi community in India. The age structures in the different decades for Parsis remaining outside Bombay are found in the census reports, and these may be used to throw some light on this question. Relevant figures are given in Table 15. It is seen that between 1901 and 1931, the population in the age group 0-15 years diminished from 34.6 per cent of the total to 30.2 per cent. There was an increase in the proportion of persons over 45 years of age, the strength in this group being 18.1 per cent of the total in 1901 and 22.4 per cent in 1931. In the age group 15-45 years there was no appreciable change during this period. The changes that have occurred in the age structure of Parsis living outside Bombay are very similar to those that have taken place amongst Parsis living in Bombay. It would therefore appear reasonable to presume that the birth and death rates of Parsis living outside Bombay have also diminished in the past few years.

Some idea of the comparative birth and death rates of Parsis living in Bombay and outside it, is provided by the figures in Table 15. The proportion of persons in the age group 0-5 is much lower amongst those who live in Bombay. The proportion in the age group 5-15 is also lower amongst them though not to the same extent. One is therefore led to the conclusion that the Parsi birth rate in Bombay is lower than that outside it, and that children living in Bombay are less exposed to the risk of death at least till they reach adolescence. An excess of births is, no doubt, a condition more favourable for population increase, but its effect will only be lasting if the mortality rates amongst children are not greater. Comparing the age structure of Parsis in Bombay and outside it, it would appear that the advantage of the high birth rate outside Bombay is lost by the time the children grow up to 15 years.

From the changes in the age structure as given by the figures in Table 15, it is clear that the Parsi population in India has been ageing.

In 1901, only 18.0 per cent of the population was over 45 years of age whereas in 1931, 22.2 per cent was over that age. The proportion under 15 years of age diminished from 32.0 per cent in 1901 to 27.2 per cent in 1931. In the age group 15-45, the proportion was fairly stationary.

The social implications of this trend in age structure deserve careful consideration. With a larger proportion of aged men and women in the community, the unproductive section is likely to increase and its maintenance, especially if state aid is negligible, will throw a greater financial burden on those in the productive age group. With this demand on their purse, the desire to keep down the family size will grow amongst the middle-aged and the birth rate will tend to diminish. In some cases, the responsibility of looking after the old in the family may prove so heavy that marriage may have to be postponed if not given up altogether by the earning members of either sex. A reduction in birth rate will normally result in a diminution of the proportion of women in the reproductive age group, which would further accentuate the diminution of the birth rate. If such a state of affairs should continue for generations, the population strength, though it may be kept up for some time by fewer deaths due to reduced mortality rates, will in all likelihood finally tend to diminish.

These are but possible consequences of such trends in fertility and mortality conditions as have been observed in the Parsi community. A more definite idea of the changes that are likely to arise in this population in the next few decades, if the present trends are unchecked, is essential for future planning and it deserves the attention of those who are interested in shaping the destiny of this community.

## THE FUTURE PARSI POPULATION

The present population position of the Parsi community has a few disquieting features. Their birth rate has reached a low level. Neither the big reduction in their mortality rates nor the occasional addition to their population by fresh immigration of Iranian Zoroastrians has been able to offset completely the effect of the diminution of the reproduction rate. The net result has been a lowering of the rate of growth of the Parsi population. The present Parsi demographic situation is similar to that of many European countries in the recent past—countries which as a consequence are now being threatened with a decrease of

population in the near future. The trend of the Parsi population in years to come is therefore a matter for serious consideration.

Forecasting the population is in the nature of making an intelligent guess. Neither the births nor deaths that will occur in the future can be foretold with any degree of certainty. A widespread epidemic may unexpectedly take a heavy toll of human lives. It may also affect the birth rate by increasing the number of abnormal terminations of pregnancy. Social values do not remain static. The frequency of marriages, the strength of marital bonds, the keenness for family life, the anxiety to take up responsibilities for additional children are determined from time to time by economic and social factors and are difficult to prophesy. Nor can the future progress of medical knowledge, its application to the improvement of public health, and the extent to which it can affect the death rates in the community, be gauged accurately in advance. What is therefore attempted in forecasting the population is merely to work out the characteristics it would possess should various factors change according to certain stipulated conditions. Even when all the uncertainties of the future are given their full importance, natural processes are relatively stable, and are subject to slow and steady variations. It is that which gives justification for making so-called reasonable assumptions of future fertility and mortality conditions which are essential for studying population trends. It is that which gives at least a practical importance to statistical estimates of the future population, which, as later events may show, may not be realised even partially.

A forecast of the Parsi population requires an appreciation of the likely changes in its mortality and fertility conditions. The statistics for the Parsis in Bombay show that the mortality conditions in the city as given by the life table for 1931 were applicable for the entire decennium 1931-41. In fact, after allowing for the effects of migration, the 1941 [6] census population was found to be nearly equal to the survivors in 1941 of the 1931 [6] census population and of the intercensal births, as worked out by means of this life table. The marked reduction that had taken place prior to 1931 in the death rates, and the difficulty of bringing into control the diseases which were still accounting for a larger number of deaths, make it reasonable to

[6] There is evidence that the census figures were in defect for the first two years of life. The populations in these age groups were estimated from the birth figures in the two previous years.

assume that no substantial change in mortality conditions from that described by the 1931 life table is likely to occur in the near future. As regards fertility, the birth rate in Bombay was stationary during 1931-41 and it seems possible that the reproductive conditions that prevailed during this period may be applicable for the next few decades, provided due attention is paid to the number of women in the reproductive age group 15-45 years.

For Parsis living outside Bombay, precise figures of birth and death rates are not available; but as pointed out in the last section, there is evidence to suggest that their birth and death rates were both in excess of those for Bombay. There is also reason to believe that the advantage of population increase gained by the excess of births would, due to the heavier mortality in the earlier age groups, be lost by the time the children grew up to 15 years. In the long run, therefore, it appears that the trend of the Parsi population outside Bombay can be worked out on the basis of the birth and death rates for Bombay City. This presumption has some warrant in the fact that the 1941 census population for the whole of India was very close to the number of survivors worked out by applying the 1931 life table for Bombay to the 1931 census population and the births in the different years as calculated on the basis of the Bombay birth rate. The Parsi population in India as given by the 1941 census was 114,890 and as estimated by us was 114,533.

The future Parsi population was therefore worked out by us under the following assumptions: (1) the influence of migration could be ignored; (2) the 1931 life table for the Parsis in Bombay could be used to work out the number of survivors; and (3) the number of births that would occur in any future year would be proportional to the number of women aged 15-45 years who would then be found in the community, and that their reproduction rate would be the same as those for the Parsi women of this age group in Bombay during 1941. The male and female population strength in 1941, and at ten-year intervals up to 2001, is given in Table 16.

It would appear that the size of the Parsi population will increase from 114,533, the estimated figure for 1941, to 115,337 by 1951. Sometime between 1951 and 1961 the population will start diminishing in numbers. In 1961 the population strength will be 113,250, and by 1971 it will be reduced by about 4 per cent to 108,648.

From 1971, every ten-year interval will diminish the population size by 6 to 7 per cent, and in 2001 the strength of the community will be 89,218, or approximately the same as the Parsi population in India in the year 1891.

This anticipated diminution in the Parsi population is simply due to the fact that the Parsis are not reproducing themselves in sufficient numbers. Unless, on an average, every female in the community is replaced by another before she dies, the population is bound to decrease

TABLE 16

*The future trend in the male and female Parsi population*

| YEAR | MALES | FEMALES | TOTAL |
|---|---|---|---|
| 1941 | 58 513 | 56 020 | 114 533 |
| 1951 | 58 463 | 56 874 | 115 337 |
| 1961 | 57 022 | 56 228 | 113 250 |
| 1971 | 54 424 | 54 224 | 108 648 |
| 1981 | 51 118 | 51 364 | 102 482 |
| 1991 | 47 605 | 48 146 | 95 751 |
| 2001 | 44 242 | 44 976 | 89 218 |

and finally become extinct. Of late, the Parsi reproductive rate has been such that 1000 females are replaced by only 830. If this state of affairs should continue indefinitely, the population will keep on diminishing by about 6 per cent every ten years after the year 2001.

Besides size, other characteristics of the population will also change during the next few decades. The sex ratio, which in monogamous societies reflects broadly the possibility of every person being able to marry in the native community, will be conspicuously affected. In 1941, the number of males in the population was in excess of females, and for every 1000 females in the community there were 1044 males. In 1951, there will be only 1028 males per 1000 females, and in 1961 the number will still further diminish to 1014. By 1971 the number of males and females will more or less balance, as there will be only 1004 males to every 1000 females. The diminution in the proportion of males will get more marked after 1971, when there will be an excess of females in the community. In 2001 there will be only 984 males per 1000 females. However, there need be no anxiety that the paucity

of males may make it difficult for women to marry in the near future, for even in the year 2001 the number of males in the age group 20-50 years will continue to be greater than the number of females in the age group 15-45 years.

The expected age composition of the population in the different decades is shown in Table 17 and Fig. 6. It is apparent that the ageing of the Parsi population that has been in progress during the last few decades will be further intensified. This tendency will continue

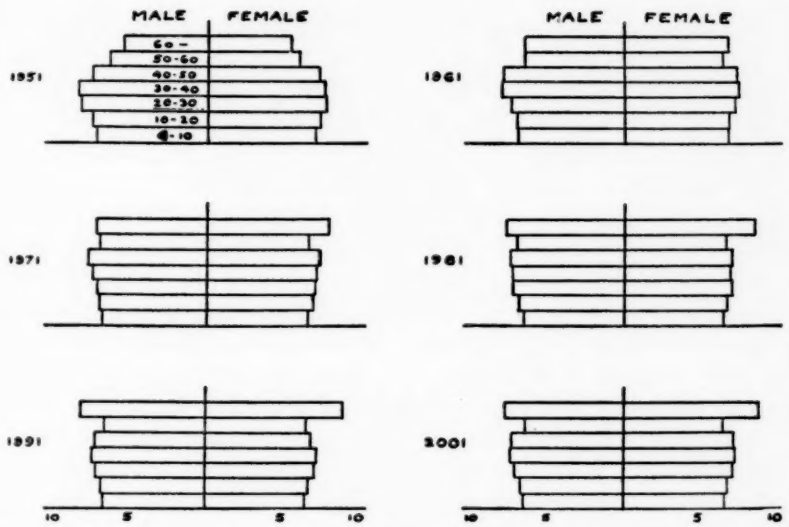


FIG. 6. EXPECTED AGE DISTRIBUTION OF PARSIS AT 10-YEAR INTERVALS, 1951-2001

until the present survivors of those born before 1931, when birth rates were higher, die out. When that occurs, the population will attain a fairly steady age distribution.

The extent to which the age composition will be affected in the next fifty years is well brought out by the following figures. In 1941 8.8 per cent of the population was 60 years of age or over. This number will increase to 11.2 per cent by 1951, 15.2 per cent by 1971, and to 17.1 per cent by 1991. After 1991 there will be a decline in the proportion of persons aged 60 years and above, and only 16.9 per cent will be found in this age group. The proportion of the population in the younger age groups will diminish after 1941 but will attain

TABLE 17

*The expected age distribution per 10,000 Parsi population*

| AGE GROUP | 1951 | | 1961 | | 1971 | | 1981 | | 1991 | | 2001 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | Males | Females | Males | Females | Males | Females | Males | Females |
| 0-5 | 363 | 359 | 349 | 345 | 339 | 334 | 332 | 331 | 331 | 332 | 334 | 334 |
| 5-10 | 352 | 350 | 346 | 344 | 336 | 334 | 329 | 331 | 329 | 330 | 331 | 332 |
| 10-20 | 748 | 744 | 700 | 697 | 697 | 693 | 688 | 684 | 681 | 684 | 683 | 686 |
| 20-30 | 826 | 790 | 739 | 734 | 708 | 703 | 716 | 712 | 714 | 710 | 709 | 712 |
| 30-40 | 837 | 788 | 805 | 760 | 736 | 722 | 718 | 704 | 733 | 719 | 733 | 719 |
| 40-50 | 757 | 736 | 794 | 740 | 781 | 731 | 728 | 707 | 715 | 694 | 733 | 712 |
| 50-60 | 631 | 603 | 650 | 653 | 698 | 672 | 699 | 675 | 656 | 659 | 647 | 650 |
| Over 60 | 554 | 562 | 651 | 693 | 714 | 802 | 777 | 869 | 813 | 900 | 788 | 897 |
| Total | 5068 | 4932 | 5034 | 4966 | 5009 | 4991 | 4987 | 5013 | 4972 | 5028 | 4958 | 5042 |

a stationary level by 1981. In 1941, 23.8 per cent of the population was below 15 years of age. This will change to 20.3 per cent by 1971 and to 20.1 per cent by 2001.

The economic implications of the changing age structure are of particular interest. For a rough appreciation of the position, it may be assumed that the male population in the age group 20-60 years has to meet the bulk of the economic needs of the entire community. In 1941, out of every 10,000 Parsis, there were 3024 males in the age group 20-60 years. By 1971 this number will change to 2923 and by 2001 it will be still further reduced to 2822. In 1941, therefore, every male adult had to bear the responsibility of providing for the needs of 3.3 individuals including himself. In 1971 the number of individuals to be cared for will change to 3.4 and in 2001 to 3.5. The economic demands made on the male adult will not increase to any marked extent between 1941 and 2001; but from the purely utilitarian point of view, the economic position in 2001 will be less satisfactory. For of the 3.3 individuals to be cared for by a male adult in 1941, 1.1 were below 20 years of age and 0.3 above 60 years of age. In later years, the responsibility towards the older age group will increase, and of the 3.5 persons to be supported in 2001, 0.6 will be above 60 years and 0.[illegible] below 20 years. It is therefore apparent that the increased demand of the older age group in the year 2001 will be satisfied by keeping down the responsibility towards the younger age group. Considering that children are potentially productive, while the bulk of those who have passed 60 years of age contribute but little to the material wealth of the community, it is clear that in 2001 as compared with 1941 a higher proportion of the community's resources will be spent on the unproductive elements in the population.

## PARSIS AT THE CROSSROADS

From humble beginnings, starting as refugees in a foreign country, the Parsis have through centuries grown into a powerful community in India. Though they number only 114,000 in a country of 400 millions, today they have a large share of interest in the industrial and economic life of the nation. Their rare powers of enterprise have undoubtedly come down from a stock of people who in the sixth century before Christ had a far-flung empire from Macedonia to the Indus Valley. Proud of their heritage, they are naturally anxious to

perpetuate it. By religious and social mores they try to maintain the identity of their community. They do not hold with religious conversion, nor is a Parsi allowed to marry outside the community. Financial embarrassment is often a danger to social cohesion, and the community has provided social amenities on a large scale to its poor and needy. Numerous bequests whose corpus runs into several crores of rupees aim to give a decent standard of living to those in want. Following the dictates of their prophet Zoroaster, marriages are encouraged with generous grants and a growth of population is welcomed.

Neither pious direction nor generous benefactions of the well-to-do can assure the preservation of a community. It is on the desire of a large part of the population for the perpetuation of the community, and the sufferings and sacrifices that they are prepared to undergo that the future of the community depends. Such a feeling should first manifest itself in an attempt to augment the size of the population. Indifference to biological growth is a sign either of despondency or of selfishness. Neither is conducive to the growth of the population or community feeling. The future of a community can be read in its demographic trends. In the foregoing pages various aspects of Parsi demography have been discussed and their effect on the growth of the community has been indicated. It has been shown that if existing fertility conditions continue unchanged the population strength will most likely start diminishing between 1951 and 1961, and in the course of a century or so it may even be reduced to half its present size. This is no happy augury for the Parsi community.

For the Parsi population to maintain its present strength, its reproductive rate must be increased by about 20 per cent; where five children are now born, the number will have to be increased to six. During the last few decades the average Parsi has found his income increasingly insufficient to meet his standard of living. As a natural corollary the age at marriage has increased and the family size decreased. In these circumstances it is doubtful if an increase in the birth rate without a corresponding increase in the family income will not prove detrimental to the health of the community and lower the expectation of life. If this be the case, an increase in the reproduction rate might not materially alter the present population trend.

While the future of the Parsi population is not encouraging from the quantitative point of view, enlightened opinion in this community has not failed to concern itself with the quality of the population.

The need of a eugenic program for the eradication of deleterious genetic characteristics is emphasized. The possible effects on the genetic traits of the community of centuries of inbreeding and of consanguineous marriages especially amongst the well-to-do are also seriously debated. The science of human genetics cannot be considered to have as yet reached a stage when it could be utilised to control to an appreciable extent the hereditary makeup of a community. Yet, as has been pointed out by Dahlberg [1] it enables us to appreciate the likely influence which some of the processes that alter the inherited characteristics of the people may produce in the course of generations. Measures directed to selective breeding and the sterilisation of the unfit can in general effect large-scale improvement only if the trait to be eliminated is relatively common. When successfully applied they would therefore markedly reduce the population strength. In the case of the Parsis the introduction of such measures would accelerate the anticipated diminution in the size of the community. On the other hand the breaking up of social barriers and the encouragement of intermarriage between different cultural groups offer promise for the reduction in the incidence of abnormal recessive characteristics which are the ones of importance in the improvement of human stock. It is for the Parsis themselves to formulate such social and population policies by which their rich heritage could be preserved and utilised for the betterment of mankind.

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[1] Dahlberg, Gunnar. Race, Reason, and Rubbish. N. Y., Columbia University Press, 1942.

# THE AUTOCORRELATION APPROACH TO THE ANALYSIS OF THE INCIDENCE OF COMMUNICABLE DISEASES

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IN studying the epidemiology of infectious diseases which are transmitted directly from man to man, it is obvious that one of the factors which determine how many persons in a community will be infected within a specified time interval is the number infected in a prior period. The contact of infected individuals and susceptibles gives rise to new cases; and if the contact rate be constant, the number of new cases will be a function of old cases and susceptible persons in the community. If such a relationship exists between the numbers of cases in successive time periods, the incidence rate observed for a particular month should furnish a basis for predicting the rate during a succeeding month. In studying diseases one attack of which confers immunity, it is necessary to take into consideration the depletion of susceptibles as they are converted by an attack of the disease into immunes. Thus, in measles, the termination of a local epidemic may be due to depletion of the susceptibles. The seasonal rise and fall of measles, on the other hand, may be explained as due to changes in the probability of transmission of the infectious agent at different seasons.

While this simple concept goes far toward explaining the basic mechanism underlying the spread of many infectious diseases, there are few situations in which it can be explicitly and mathematically applied at present. With respect to most diseases it is impossible to identify the immunes and susceptibles, and the problem is further complicated by the occurrence of inapparent or unrecognized infections

* The author wishes to express appreciation to Dr. Philip E. Sartwell, Assistant Professor of Epidemiology at the Johns Hopkins University School of Hygiene and Public Health, for his invaluable suggestions and assistance in connection with this paper.

in persons who are able for longer or shorter periods to transmit these infections to others.

Nevertheless, it is usually possible to see a general relationship between the number of recognized cases of a communicable disease in successive time periods. The incidence of acute respiratory diseases among the population of Army troops in the United States usually increases fairly markedly from November to December, and almost invariably drops from March to April. A month's incidence rate is, then, influenced by both the previous month's rate and by its position in the seasonal cycle. The rate of incidence in month $m$ can thus be thought of as depending upon: (1) the incidence rate during month $(m - 1)$; and (2) other variables acting during the current period, which affect the transmissibility of the disease. The incidence rate in a particular month might provide a basis for predicting a succeeding rate within statistically defined limits of accuracy. If the rate for a disease during January is correlated with that for February, and if, furthermore, that for February is correlated with that for March, then there will be some correlation between the January and March rates. Such correlation might be extended between months $m$ and $m + 3$, $m$ and $m + 4$, and so on up to $m$ and $m + n$, at which point whatever correlation might exist would be close to zero.

To test the degree of correlation existing between incidence rates in successive time periods, monthly common respiratory disease and influenza incidence data for the United States Army over a period of 40 years were analysed. The diseases reported in these categories are a large and diverse group, caused by a variety of etiologic agents. Among the known pathogens which produce illnesses falling in this class are the influenza viruses, the streptococci and pneumococci. The common cold, for which one or several unknown but presumably viral agents are responsible, contributes a large share of the morbidity, and various other acute infectious diseases are doubtless included. In addition, it is likely that a small proportion of these cases are non-infectious, an example being allergic conditions of the upper respiratory tract. All rates dealt with in this paper are based on the combined incidence, as diagnosed and reported, of catarrhal bronchitis, acute coryza, acute catarrhal pharyngitis and laryngitis, and influenza. Pneumonia is also included in data prior to 1925, but the relatively small number of pneumonia cases does not introduce any serious difference between the earlier and later periods. Rates for the period from 1906

to 1925 were obtained from tabulations of individual medical records, while those for subsequent years were calculated from periodic summary reports *(Statistical Health Reports)* of Army installations. The rates are based on the experience of Army personnel stationed within the United States. Both the size of this force, and its composition, have varied widely over the past 40 years; during periods of mobilization and war the Army has been younger in terms of average length of military service, and probably more representative of the general civil population from which it was drawn, than at other times.

During the 40-year period there has been no distinct long-time upward or downward trend in the annual level of respiratory disease incidence; there has, of course, been a continuous, marked, and fairly regular seasonal rise and fall, the incidence being low in the summer and early fall. The variation in summer rates is much less than in winter rates and is generally considered insignificant, but may nevertheless be important in forecasting winter rates.

The problem, for present purposes, is to correlate successive months' incidence rates, eliminating seasonal fluctuations. In other words, knowing that December rates are generally higher than the preceding November rates, do we find that the higher the November rate is observed to be, the higher will be the December rate? And do we find that a relatively high September rate is usually an indication of high winter rates to follow? The usefulness of answers to these questions is evident. Not only would they afford a basis for planning of hospitalization and medical care, but they might aid in the study of other factors influencing morbidity, the effect of which would otherwise be obscured.

Before discussing the methods of analysis and their results, it is desired to stress the fact that this is a study of the mass occurrence of a heterogeneous group of diseases as recorded in large populations scattered over wide areas. It is necessary to bear in mind that there are many highly important factors which influence the occurrence of specific infections, such as the proportion of "unseasoned" troops in the Army at different times, the impact of a sharp epidemic of influenza A or B in a particular year, or the effect of a regional epidemic of streptococcal infections.

The existence of significant autocorrelation between respiratory disease incidence rates in the Army may be shown in two ways. The first method is to determine the correlation between calendar months

$m$ and $m + n$ for each year for all troops in the United States. Graphically this is illustrated in the scatter diagram of Fig. 1, where the abscissa stands for the number of cases of respiratory disease per 1000 troops per year experienced by the population of Army troops stationed

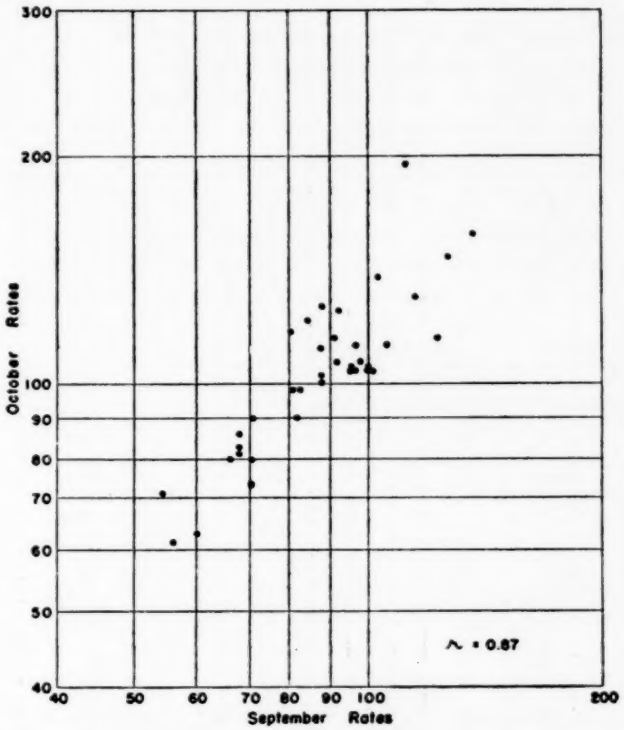



FIG. 1. RELATION BETWEEN THE SEPTEMBER AND OCTOBER RATES OF INCIDENCE OF RESPIRATORY DISEASE AMONG U. S. ARMY TROOPS STATIONED IN THE UNITED STATES, 1906-1946

Rates are expressed as cases per thousand troops per year.

in the United States during September, and the ordinate represents the corresponding October rate for the same year, each point representing a different year (or season in the event that the earlier month is in one calendar year and the later month pertaining to the same point on the chart applies to the succeeding calendar year, such as would be the case in correlating January rates of incidence with December rates).

The second way in which positive autocorrelations of respiratory disease rates in the Army can be seen is in the plotting of data by Army camps, posts, or stations in the United States, holding the year (or season) constant. In Fig. 2 the horizontal component of a point indicates the

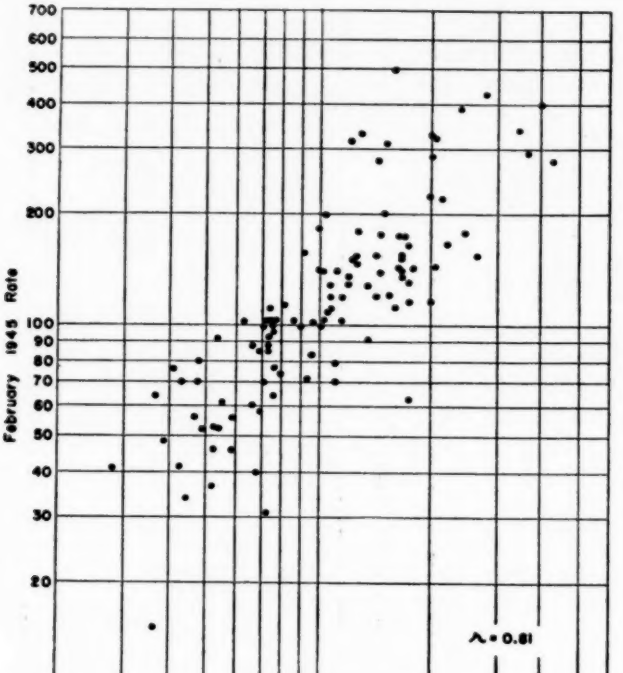



FIG. 2. RELATION BETWEEN THE JANUARY AND FEBRUARY 1945 RATES OF INCIDENCE OF RESPIRATORY DISEASE AT ARMY INSTALLATIONS IN THE UNITED STATES

Rates are expressed as cases per thousand troops per year.

rate of incidence of respiratory infection at a particular camp, post or station during January 1945, while the vertical reading represents the corresponding rate for the same installation during the succeeding month, i. e., February 1945. In this chart each point corresponds to an individual Army camp, post, or station in the United States.

Only camps in which a minimum troop strength of 4500 was maintained were included in this chart as well as those of Figs. 7, 8 and 9. Installations which served as basic training centers were excluded, since it was thought that the higher incidence of respiratory disease among recruits could result in an upward bias of the correlation coefficients.

In the figures shown, the horizontal and vertical scales are drawn logarithmically, and in all calculations of the correlation coefficients and related measures the logarithm of the incidence rates rather than the rates themselves are employed. The use of the logarithmic transformation is indicated because of the more evident linearity obtained, thus involving simpler calculations, and because the data then appear to be more nearly drawn from normally distributed populations so that the interpretation of such statistics as the standard error of estimate and the coefficient of correlation need not offer any special difficulties.

In the discussion that follows, data of the type illustrated in Fig. 1, where each rate discussed pertains to incidence for the entire troop strength stationed in the United States for each particular month, will be referred to as total Army-in-U. S. data since each correlation is based on Army-wide rates observed over many years among troops stationed in the United States as a whole, and data of the type shown in Fig. 2 will be referred to as data by installation (as noted above, in this case each correlation is based on rates observed at various Army posts, camps, and stations in the same year). The data used in the correlations of the total Army-in-U. S. rates are taken from Army Medical Department sources, for the period dating from January 1906 through May 1947, with the exception of the years 1916 and 1917, for which data were not available.

In the correlation analysis of the total army data, the question arose as to whether the monthly rates for the influenza pandemic of 1918-19 properly belonged in the correlations. As will be recalled, the last few months of World War I witnessed the most disastrous onslaught of influenza in the past half-century. During the period of this pandemic there were more than 20,000 deaths among United States Army troops attributed to it. The possible tendency toward over-diagnosis, the effect of troop movements into and out of the country, and the fact that this was the only such experience in the past 45 years, raise legitimate questions as to whether incidence rates for the pandemic months can be regarded as belonging to the series

for the other years. In general, the inclusion of this period produces small change in the coefficients of correlation. It was also observed that the dispersion of points for the period of World War II seemed typical of the other years.

Out of the last 38 winters for which complete monthly data on the incidence of respiratory disease among U. S. Army troops stationed in the United States are available, three peak rates occurred in December, eleven in January, fourteen in February, nine in March, and one in October. The peak October respiratory disease rate of 2032 cases per 1000 strength per year was reached in 1918 during the influenza pandemic. It was the largest month's incidence of respiratory disease among the population of U. S. Army troops stationed in the United States during the period for which we have data. It is of some interest to observe that the approach to this record peak rate, upon casual examination of some of the preceding rates, may seem rather sudden (the rates for July, August, and September of 1918 were 130, 148, and 864 respectively) so that the extremely high October or September-October incidence might appear completely unpredictable, or at least, there was small statistical indication of the high September and October levels that followed. However, upon further study, it is noted that, while a rate of 148 is generally regarded as "low," such an evaluation is valid only for winter months. Actually, the rate of 148 cases per 1000 men per year experienced among troops in this country during August 1918 was the second highest August incidence on record in the years from 1906 through 1947. The July 1918 rate of 130 was also the second highest July respiratory disease rate during these years, and the June rate of 137 was the third highest June rate. Going back a few months, it is noted that the March 1918 rate of 533 was the highest March rate on record in the period 1906-1947, the April rate of 625, the highest April, and while the rate dropped from 625 in April to 259 in May of 1918, the latter was nevertheless the second highest May figure over the years discussed. Hence, of the seven months preceding the record October peak, three experienced the highest rate among corresponding months over the years 1906-1947, three were second highest, and one was third.

Thus, if one were to consider the experience of the pandemic year as properly belonging to the group of observations of the other years, it is quite apparent that the statistics of respiratory disease incidence during the pandemic support the existence of positive autocorrelation

of incidence rates of respiratory disease. As has been indicated above, the actual numerical results obtained after including the rates during the pandemic year differ only slightly, on the average, from the results obtained without their inclusion. The numerical values discussed below, and the scatter charts presented, do not include the observations from June 1918 through May 1919, covering the pandemic period.

The value of $r_{n,\,n+1}$, the coefficient of correlation between the logarithms of the respiratory incidence rates for the months $n$ and $n+1$, when calculated from the total Army-in-U. S. data averages to .84. The highest of the 12 values (.89) occurred in the August-September correlation; the lowest was .71, and was calculated from the December-January data (see Table 1).

TABLE 1

*Coefficients of correlation between respiratory disease incidence rates of consecutive pairs of calendar months*
*(Total Army-in-U. S. data, 1906-1947)*

| MONTH-PAIR | CALCULATED VALUE OF $r_{n,n+1}$ |
|---|---|
| Jun -Jul | .87 |
| Jul -Aug | .88 |
| Aug -Sep | .89 |
| Sep -Oct | .87 |
| Oct -Nov. | .87 |
| Nov-Dec | .84 |
| Dec -Jan | .71 |
| Jan -Feb | .73 |
| Feb -Mar | .87 |
| Mar-Apr | .84 |
| Apr-May | .88 |
| May-Jun | .87 |

Although these coefficients do not appear to differ significantly, (which is the same as stating that if each of the twelve sets of paired rates are regarded as samples from 12 populations, these samples could reasonably have been drawn from populations whose true coefficients of correlation are equal) the possibility of true differences among sub-groups of these correlations is not precluded. While no seasonal

trend is observable in the correlation values, the two lowest calculated coefficients occurred in winter months, when it seems more likely that violent and sudden changes in factors which are capable of affecting the autocorrelations of respiratory disease incidence rates may take place. However, in the logarithmic transformation a "sudden" increase in the rate from 25 to 75, such as might occur in summer, is comparable to an increase from 250 to 750 during the winter, so that if pre-seasonal environmental changes contributing to the former increase should occur with about the same frequency (though perhaps not as dramatically) as conditions causing the comparable winter increase, one need not expect the general level of environmental differences to affect the underlying correlation values. Aside from these considerations, the following points should be considered with respect to the December-January and January-February results:

(1) In practice, lower than average correlations for these months would imply a generally lesser degree of predictability. However, while the value of $r$ for December-January is .71 against an average $r_{n,\,n+1}$ of .84, the November-January value is .79, against an average $r_{n,\,n+2}$ of .69, and compares rather favorably, for example, with the .73 correlation between June and August. Similarly, the October-February correlation of .68 is higher than the $r_{n,\,n+4}$ average of .61.

(2) Variation from year to year in Army policy respecting the granting of furloughs during the Christmas-New Year holidays may have resulted in a downward bias in the December-January correlation and to a lesser extent perhaps in the January-February correlation. Errors in incidence rates based on data from periodic summary reports during the holiday season may occur as a result of the absence of large numbers of men from Army posts; these men enter into the Army population count, but may not be included in the count of cases if they develop minor illnesses while on furlough.

(3) Correlations by Army installations also give evidence indicating that the deviations of the December-January and January-February correlations from the average were either due to chance, to the varying leave factor, or both. Thus while $r_{n,\,n+1}$ for the correlations by Army installations from September 1943 through June 1947 averages to about .75, the results shown in Table 2 were obtained in the December-January and January-February correlations during that period.

In Fig. 3 the average values of $r_{n, n+x}$ are plotted against $x$ as the horizontal ordinate. As is to be expected, increasing the number of months between the predicting and predicted months has the effect of reducing the value of the correlation coefficient. While $r_{n, n+1}$ for the Army-in-U. S. data averaged .84, the average $r_{n, n+2}$ calculated for the same data is .69. The value of $r_{n, n+x}$ tends to drop more slowly as $x$ increases. Thus, it is not until $x = 8$, that the calculated average

TABLE 2

*December-January and January-February correlations, 1943-47*

| | COEFFICIENT OF CORRELATION | NUMBER OF INSTALLATIONS |
|---|---|---|
| Dec. 1943- Jan. 1944 | .63 | 147 |
| Jan. 1944- Feb. 1944 | .77 | 142 |
| Dec. 1944- Jan. 1945 | .84 | 111 |
| Jan. 1945- Feb. 1945 | .81 | 111 |
| Dec. 1945- Jan. 1946 | .73 | 55 |
| Jan. 1946- Feb. 1946 | .80 | 48 |
| Dec. 1946- Jan. 1947 | .58 | 21 |
| Jan. 1947- Feb. 1947 | .76 | 21 |

$r_{n, n+x}$ approximates .55. In general then, the farther in advance we attempt to predict the rate for a winter month, the less the accuracy of the prediction. This follows directly from the formula,

$$S^2_{n, n-x} = \sigma^2_n \left(1 - r^2_{n-x, n}\right)$$

where we regard the $n$-th month as the month for which the prediction is to be made, and $x$ as the variable number of months in advance of $n$. As $x$ increases and $r_{n-x, n}$ decreases, the value of $\sigma_n$, the standard deviation of the logarithms of the rates of month $n$, remains constant, and the value of $S_{n, n-x}$ must increase. The latter, of course, represents the standard error of estimate about the regression line used in the prediction of the incidence rates in month $n$ from those of month $(n - x)$; the larger the value of $S_{n, n-x}$ the smaller is the chance that the error in the prediction will be less than any fixed percentage. This is illustrated in Figs. 4 and 5, in which the November-January and October-February relations are shown. In these charts the respective

regression lines, fitted by the method of least squares, can be used to predict the January rate from the preceding November rate, and the February rate from the preceding October. In Fig. 4, for example, a reading on the vertical scale off the regression line (drawn solidly through the scatter of points) is interpreted as the average January

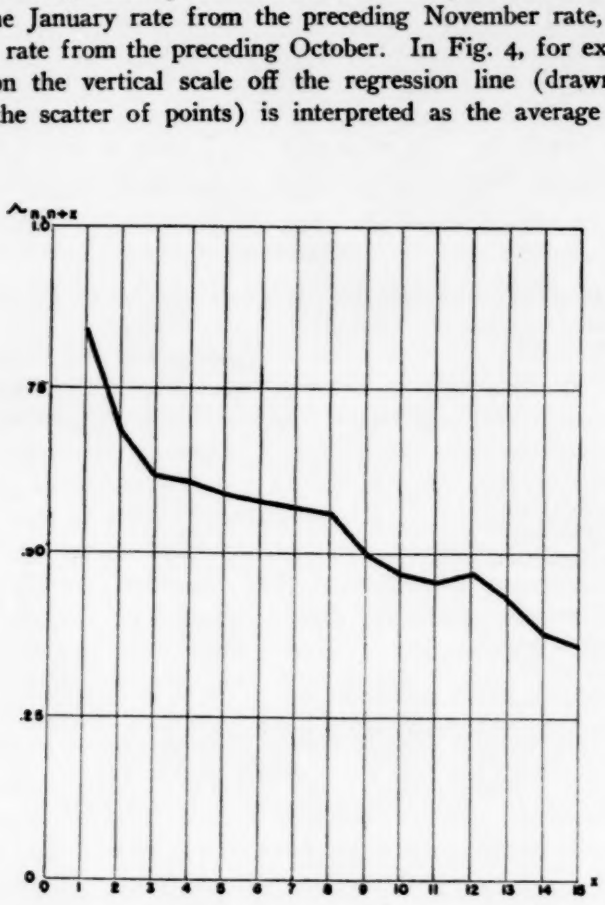



FIG. 3. AVERAGE VALUE OF OBSERVED $r_{n,\,n+x}$ SHOWING THE DECLINE IN THE CORRELATION COEFFICIENT AS THE NUMBER OF MONTHS BETWEEN THE PREDICTING AND PREDICTED MONTHS INCREASES

rate to be expected for the corresponding (observed) November rate. The two dashed lines, drawn above and below the regression line, and parallel to it are the plus and minus two standard error boundaries between which it is estimated approximately 95 per cent of the observations will fall.

The regression line and the standard errors involved can also be of value in appraising the effectiveness of programs of control of respiratory disease. For example, following the observation of a fairly high incidence rate during the month of November, it may be decided to employ some new measure aimed toward greater control of the spread of infection. If this measure is carried out for the most part by the end of December, and it is judged that, if the measure is an

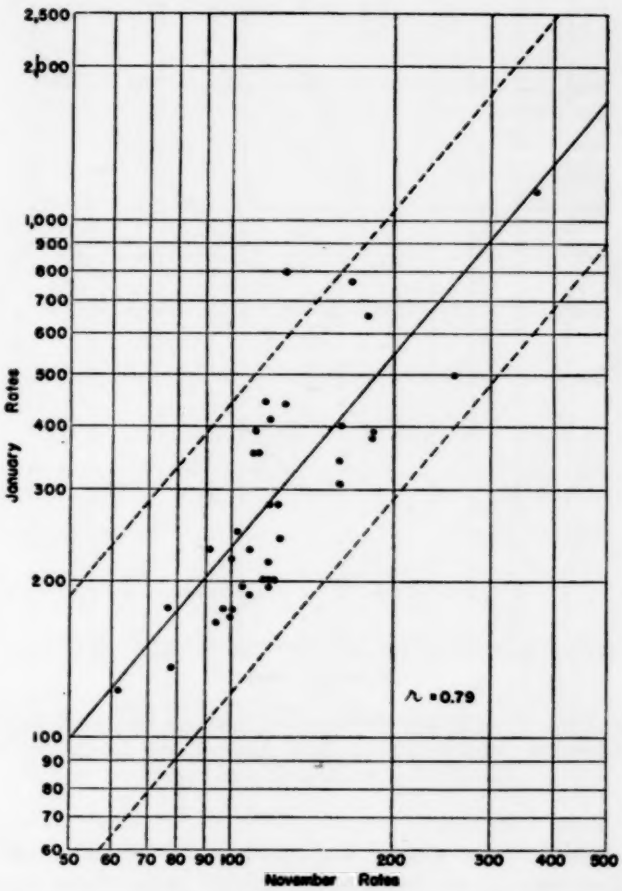



FIG. 4. RELATION BETWEEN THE NOVEMBER AND JANUARY RATES OF INCIDENCE OF RESPIRATORY DISEASE AMONG U. S. ARMY TROOPS STATIONED IN THE UNITED STATES, 1906-1946

effective one its effect will have been felt by January, the November-January point for that season can be plotted as soon as the January rate becomes available. Then, if the point falls within plus or minus two standard errors about the regression line (between the two dashed lines) this would be evidence against the effectiveness of the measure taken. If the point were to fall below the lower of the dashed lines,

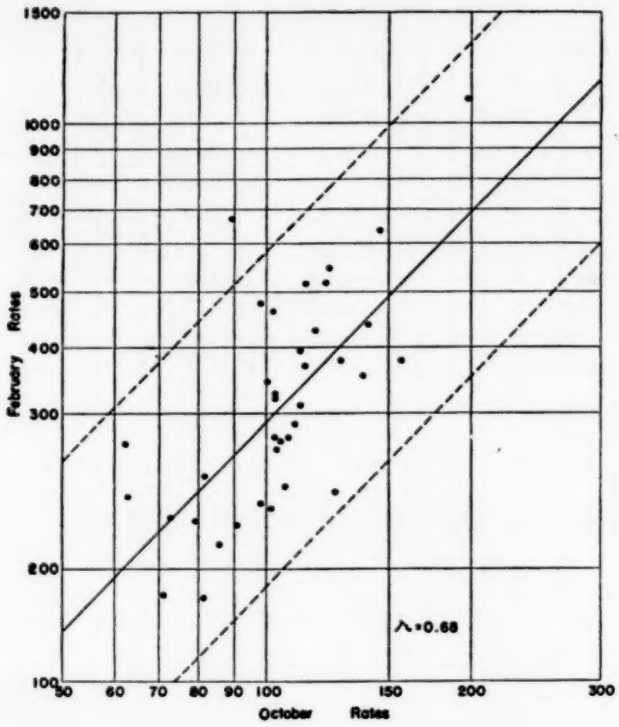



FIG. 5. RELATION BETWEEN THE OCTOBER AND FEBRUARY RATES OF INCIDENCE OF RESPIRATORY DISEASE AMONG U. S. ARMY TROOPS STATIONED IN THE UNITED STATES, 1906-1946

it would provide some statistical support for the effectiveness of the control measure. If the point were to fall above the upper dashed line, and there were no other apparent causes operative that would tend to produce a significantly higher rate in January than would normally be expected following the observed November rate, the

question would arise as to whether the measures taken were not actually detrimental in some way. It is to be emphasized that this procedure as a method of evaluation should not generally be regarded as conclusive in itself, but should rather be considered as evidence favoring one or another viewpoint, or in support of other evidence. This is especially true until the effect of other possible influences on

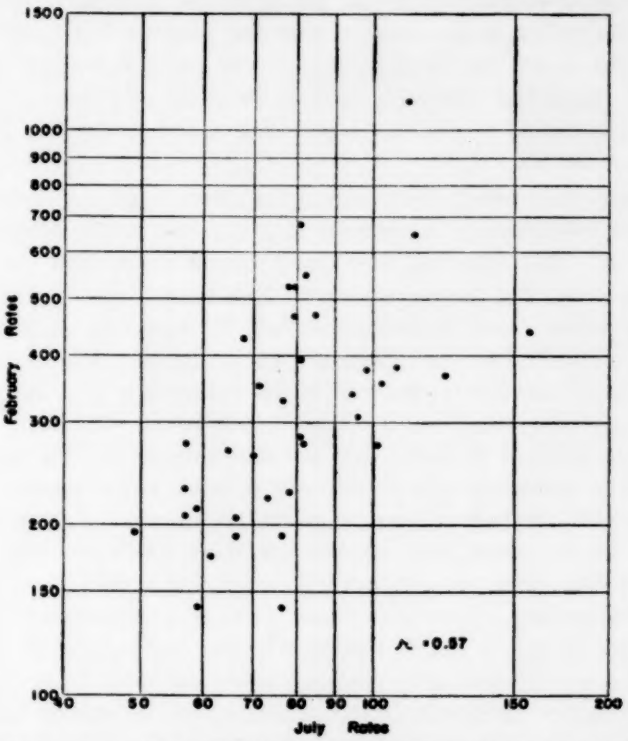



FIG. 6. RELATION BETWEEN THE JULY AND FEBRUARY RATES OF INCIDENCE OF RESPIRATORY DISEASE AMONG U. S. ARMY TROOPS STATIONED IN THE UNITED STATES, 1906-1946

the rate of incidence of respiratory disease has been measured. Since the correlations in this paper are based upon the combined incidence of a group of respiratory diseases, the effect of a control measure against a specific respiratory disease in this case manifestly further limits the procedure, and when the specific disease against which the control measures are taken generally comprises only a small proportion

of cases in the combined group, the effect of the measures taken could hardly be assessed in this manner.

Although the value of $r_{n,\,n+x}$ declines with increasing $x$, it does not drop so rapidly that rates observed during the summer months offer no information regarding seasonal incidence of respiratory disease. To illustrate, Fig. 6 shows that of the 12 years in which the July rate of incidence of respiratory disease among troops stationed in the United States was 70 cases per 1000 troops per year or less, only in one case did the succeeding February rate exceed 300 (the median February rate over the period 1906-46 is 310) while of the 25 years in which the July rate exceeded 70, 18 or 72 per cent of the succeeding February rates exceeded 300.

Of some theoretical importance is the question of the rapidity with which the coefficient of correlation $r_{n,\,n+x}$ approaches zero with increasing $x$. That is to say, how many months apart must the data be plotted in order that the correlation be "practically" zero? The answer to the question (in a particular context) of how large a value of $x$ is required such that the incidence rate in the $n$-th month will have practically no bearing on the rate to be expected in the $(n + x)$-th month, may be applicable to a situation such as the following:

Taking seasonal variation into account, suppose a sequence of unusually low incidence rates is observed in some large community over many months, perhaps a year or more. A question may arise as to whether or not some basic change has taken place resulting in this series of low rates, or whether the latter are merely the result of chance fluctuations. Now in the more usual type of statistical problem, (analogous in public health statistics to the comparison of incidence rates of a noncommunicable disease) when the rates to be compared are statistically independent, the problem can be solved simply by applying the formula for the standard error of the difference between two percentages in testing for significant differences. However, in a situation where each rate influences each succeeding rate and a chain of favorable rates may be started by a single (chance) atypically low rate of incidence, or by a gradual series of decreasing rates to one which is atypically low, the problem of how long it would take for the sequences of rates in the chain to overcome the influence of the first atypical rate (which may be regarded as generating the chain) is precisely the length of time it would take for the correlation to be zero. A protracted series of extremely low rates extending appreciably

beyond such a period would give evidence to support a hypothesis for an underlying change, i. e., for other than chance factors alone to have affected the sequence favorably. It might be pointed out, that where a suspected basic underlying cause is in operation for a comparatively short time interval, this particular approach would obviously not apply. In such a case a test that could be applied is that involving the stan-

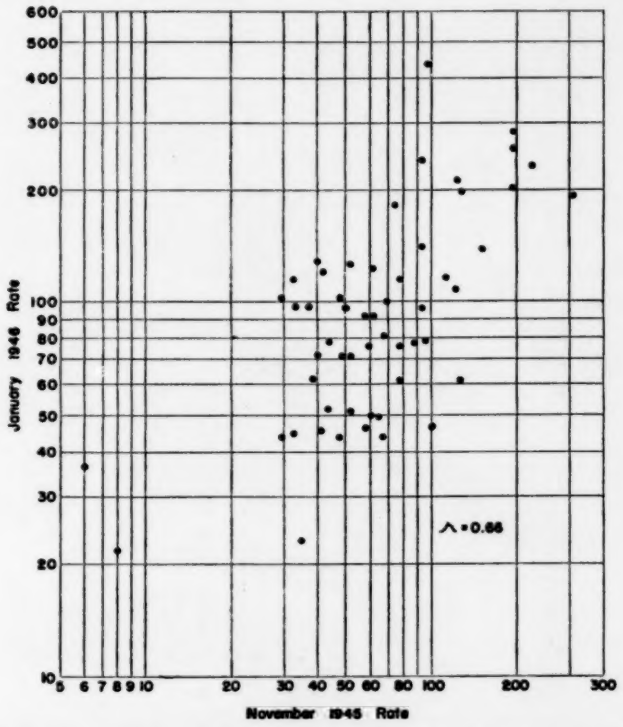



FIG. 7. RELATION BETWEEN THE NOVEMBER 1945 AND JANUARY 1946 RATES OF INCIDENCE OF RESPIRATORY DISEASE AT ARMY INSTALLATIONS IN THE UNITED STATES

dard error of estimate about the regression line, as indicated earlier in this paper.

Turning our attention to the statistics of respiratory disease incidence at individual Army installations, the phenomenon of autocorrelation is again strongly evident, although, in general, it appears that the

correlations calculated by Army installations are somewhat lower than the values of the total Army-in-U. S. correlations, for corresponding lags. Factors which may be responsible for the differences are: (1) the incidence rates used in the correlations by installation are based on much smaller populations of troop strength than those using all troops in the United States as the population to which cases are related,

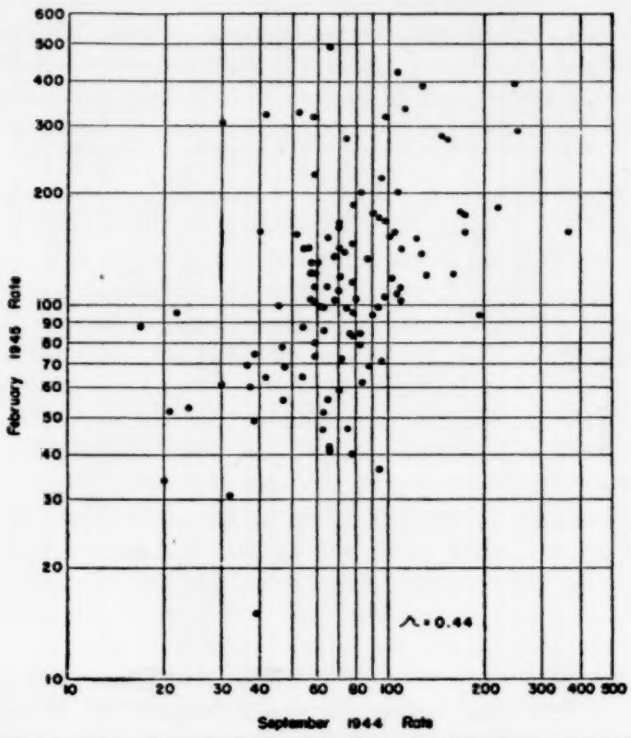



FIG. 8. RELATION BETWEEN THE SEPTEMBER 1944 AND FEBRUARY 1945 RATES OF INCIDENCE OF RESPIRATORY DISEASE AT ARMY INSTALLATIONS IN THE UNITED STATES

thereby providing a lesser degree of statistical reliability in the former; (2) gross errors in reporting the incidence of respiratory disease at a particular installation, such as an error of omission which might occur during maneuvers, on the summary reports from which these data were obtained, though of infrequent occurrence, may bias the installation correlations downward, but would hardly affect the total

Army-in-U. S. rates; and (3) the transfer and movement of troops between the different posts, camps and stations has the effect of changing the actual populations at the particular installations over relatively short periods of time, while leaving practically unchanged the population of Army troops as a whole.

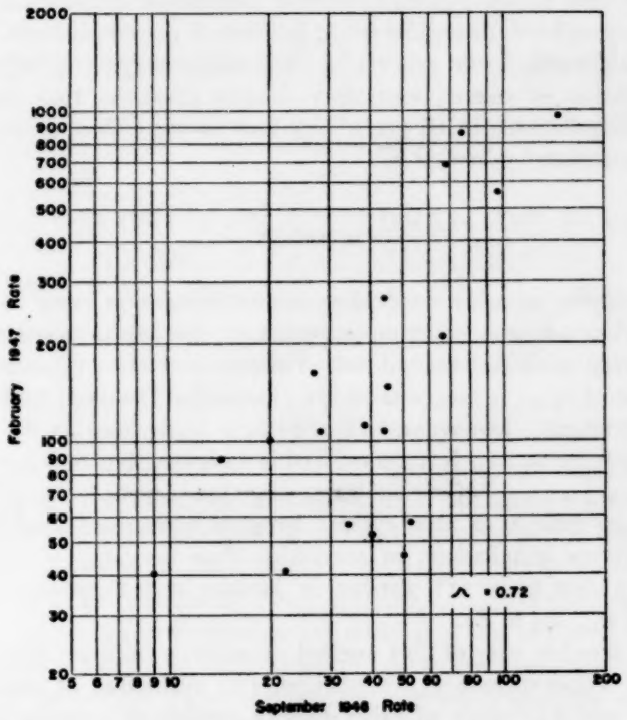


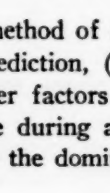

FIG. 9. RELATION BETWEEN THE SEPTEMBER 1946 AND FEBRUARY 1947 RATES OF INCIDENCE OF RESPIRATORY DISEASE AT ARMY INSTALLATIONS IN THE UNITED STATES

The January-February 1945 correlation (see Fig. 2) of .81, based on data from 111 installations, is somewhat higher than the corresponding average value of $r_{n,\,n+1}$ taken by installation for all consecutive pairs of months from September 1943 through June 1947. This average was .75, compared with the corresponding average of .84 for the $r_{n,\,n+1}$ of the total Army-in-U. S. data. Typical scatters for

$r_{n,n+2}$ and $r_{n,n+8}$ are illustrated in Figs. 7 and 8 respectively. In separating the camps plotted in Fig. 2 geographically into the six administrative Army areas, it was found that correlations performed on each of these six groups of stations yielded values which averaged .81, approximately the same value obtained when all were plotted on the same grid (Fig. 2). Hence, it would appear that very little, if any, positive bias in the station-by-station correlation coefficients resulted from geographical differences in the location of the installations. Differences in the diagnostic criteria or hospitalization policies with regard to admission of minor respiratory disease cases, as they may exist among installations, in all probability had no more than a slight effect on the calculated values of $r$.

## SUMMARY

Employing monthly respiratory disease admission rates for United States Army troops covering a period of 40 years, month-to-month autocorrelations have been studied. Between successive calendar months the value of $r_{n,n+1}$ ranges from .71 (December-January) to .89 (August-September). The average value of $r_{n,n+x}$ declines as the interval, $x$, between the months being compared is increased, but remains above .5 up to $r_{n,n+9}$.

Autocorrelation is also evident between admission rates for individual Army installations in successive time periods. For example, based on data from 111 stations in January and February 1945, the value of $r_{n,n+1}$ is .81.

The possible uses of this method of analysis of mass data are discussed. These include (1) prediction, (2) evaluation of measures of control, and (3) study of other factors capable of affecting the incidence of communicable disease during a period, the effects of which would otherwise be masked by the dominant influence of the previous level of infection.